







fig. 1.

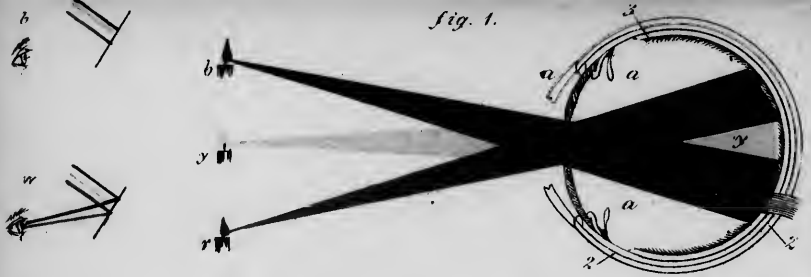


fig 2.

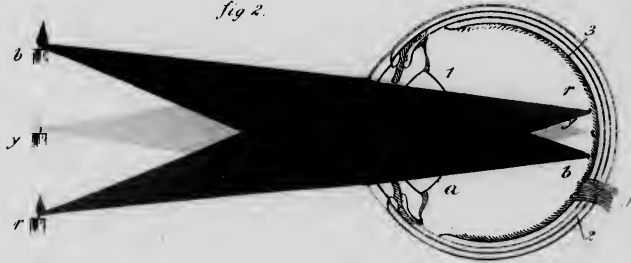


fig. 3.

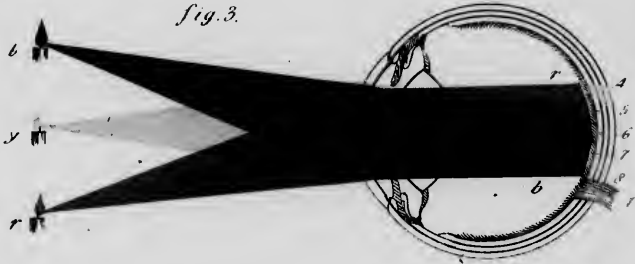


fig. 4.

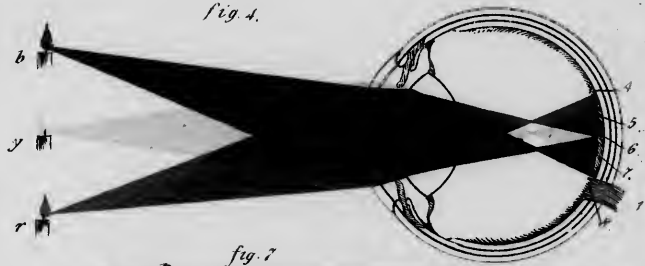


fig. 8.

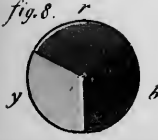


fig. 7



fig. 5.



fig 6

u.

l.

fig. 9.



HUMAN BIOLOGY.

HUMAN BIOLOGY.

DESCRIPTION OF SMALL LITHOGRAPHIC PLATES.

PLATE 1 represents a back view of a part of the nervous system exposed by removing the skin, some of the muscles, the back part of the spinal column, and a portion of the back and lower part of the skull. Above, a small part of the lower and back part of the cerebrum is seen convoluted like a peach-stone. Below it, the smoother cerebellum is represented. From the skull the spinal cord is seen extending the whole length of the back, and from it on each side nerves are seen extending towards all parts of the body, the large sciatic of the leg being very conspicuous. For particulars, see description of large Plate 3.

PL. 2 represents the muscles and tendons as they appear when the skin is removed, except that the external muscles are also removed from the left side. The direction of the stripes shows the direction in which the muscles and their parts contract, and of course the direction in which they have a tendency to produce motion. For particulars see description of large Plate 2.

PL. 3 represents a side view of the osseous skeleton. 1. Frontal bone; 2, parietal bone; 3, its posterior border; 4, occiput; 5, nose; 6, eye sockets; 7, teeth; 8, lower jaw; 9, 10, spinous processes of cervical vertebræ; 14, clavicle or collar bone; 15, sternum or breast bone; 16, scapula or shoulder-blade; 17, 18, ribs; 19, humerus; 20, ulna; 21, radius; 22, wrist; 23, metacarpus; 24, phalanges or finger bones; 25, femur; 26, patella or knee-pan; 27, tibia; 28, fibula; 29, ankle; 30, metatarsus; 31, phalanges of foot. For particulars see description of large Plate 12 (*not yet published*).

PL. 4, FIG. 1 represents a view of the large blood-vessels in their relative positions in the body. Red represents arteries; blue, veins; *a*, aorta, where it leaves the heart; *b*, carotid A. and jugular V.; *c*, subclavian A. and V.; *d*, brachial A.; *e*, radial A.; *f*, ulnar A.; *h*, superior mesenteric A.; *i*, renal A.; *j*, inferior mesenteric A.; *l*, femoral A.; *m*, tibial A.; *n*, peroneal A.; *o*, descending, *p*, ascending vena cava; *q*, diaphragm; *r*, renal V.; *s*, cephalic V.; *t*, saphena V.

FIG. 2 is an ideal view of the right and left or pulmonary and systemic hearts. R. A. right auricle into which S. V. systemic veins open; R. V. right ventricle into which the right auricle opens, and from which P. A. pulmonary artery opens out; L. A. left auricle into which P. V. open, L. V. left ventricle into which L. A. opens, and from which S. A. systemic artery opens out.

FIG. 3. An ideal representation of the circulation. The dart points with the course of the blood. The initials of the parts through which the blood flows are given.

FIG. 4 is an ideal representation of the circulation of the blood. The initials indicate the parts. (See description of large Plate 6.)

PL. 5, FIG. 1 represents a view of some of the larger lymphatic vessels and glands, exposed by removing the skin, some of the muscles, the front part and organs of the chest and abdomen. A. receptaculum chyli, into which the lacteals and lower lymphatics discharge their contents, and from which the thoracic duct leads up to open into the neck veins.

FIG. 2 represents the arm raised and parts removed, to show the numerous lymphatics of the axilla or armpit.

For particulars, see description of large plate 10 (*not yet published*).

PL. 6, FIG. 1. View of section of skull, face, and spinal column through the centre, and side view of brain, spinal cord, and organs of chest and abdomen; *c*, cerebrum; 2, floor of the skull; *f*, frontal sinus; *b*, turbinated bones; *n*, nasal fossæ; *m*, chin; *t*, throat; *p*, spinous processes of the back; *m*, dura mater enveloping the spinal cord; *p d*, right lung; *d*, diaphragm, a piece of it is removed to show *f*, the liver; *s*, stomach; *cæ*, cæcum; *c c*, colon; *i*, second stomach.

FIG. 2. A, Valves of aorta; B, ascending aorta; 1, left, 2, right coronary A.; C, innominate A. D, subclavian A.; 1, vertebral; 2, internal mammary; 3, inferior thyroid; 4, its ascendant branch; 5, transversalis colli; 6, transversalis humeri; 7, first and second intercostals; 8, suprascapular. E, axillary A.; 1, superior thoracic; 2, thoracic longior; 3, thoracica humeraria; 4, subscapular; 5, posterior; 6, anterior circumflex. F, brachial A.; 1, profunda humeri; 2, anastomotie major. G, radial A.; 1, recurrens; 2, superficialis volæ; 3, palmaris profunda. H, ulnar A.; 1, recurrens anterior; 2, posterior; 3, dorsalis; 4, palmaris. J, interosseous A.; 1, superior perforans; 2, recurrens. K, carotid A.; L, external carotid; 1, Thyroid superior; 2, lingual; 3, labial; 4, occipitalis; 5, posterior auris; 6, maxillary internal; 7, transverse facial; 8, temporal. M, internal carotid A.; 1, anterior; 2, medial cerebri; 3, communicans. N, vertebral A. O, basilar A.; 1, communicans; 2, posterior cerebri. P, thoracic aorta; 1 to 10 intercostals. Q, abdominal A.; 1, phrenic; 2, celiac; 3, coronary; 4, hepatic; 5, splenic; 6, superior mesenteric; 7, capsular; 8, emulgents; 9, inferior mesenteric; 10, lumbar; 12, medial sacral. R, common iliac A.; S, internal iliac; 1, obturator; 2, gluteal; 3, ischiatic; 4, pudic. T, external iliae A. U, femoral A.; 1, epigastric; 2, circumflex ilii; 3, profunda, *a*, external, *b*, internal circumflex, *c*, perforans. V, popliteal A.; 1, internal; 2, external superior articular; 3, medial; 4, external inferior; 5, internal articular. X, anterior tibial A.; 1, recurrens; 2, internal; 3, external malleolar; 4 tarsal. Y, posterior tibial A.; 1, external; 2, internal plantar. Z, fibular A.; 1, anterior; 2, posterior.

PL. 7. Front view of the system, with the skin and front part of chest and abdomen removed. *r*, temporal muscle; *o*, orbicularis; *q*, quadratus; *p*, platysma; *s*, sterno-cleido-mastoid; *d*, deltoid; B. biceps; *s*, supinator; *a*, sartorius; D. rectus; L, knee-pan; *p*, lungs; *e*, heart-case; *d*, diaphragm; *s*, stomach; *f*, liver; *c' c' c'*, colon; *i*, second stomach.

PL. 8, FIG. 1. *b*, *y*, *r*, candles giving off blue, yellow, and red light; it passes in all directions, but only such rays are represented as will enter the eye, which is here represented without refracting media. 1 represents the optic nerve, terminating in thousands of points, which form the ideal retina. Upon these the light falls in direct

lines, and that from each candle acts over much surface, and that from two different candles also acts upon some of the same nerves; distinct vision cannot therefore be caused with such an eye.

FIG. 2 represents the eye and its refracting media. The light from each candle intensely acts on different points of the retina, producing clear vision, and also allowing the direction of objects to be judged.

FIG. 3 is an exaggerated representation of a "long-sighted" eye. The light is not refracted sufficiently.

FIG. 4 is an exaggerated representation of the "short-sighted" eye.

FIG. 5 is an ideal representation of light from two points acting on one nerve *d*. *b*., through which a single sensation would be caused, and apparently only one object seen.

FIG. 6 represents two kinds of light acting on two nerves, through which two sensations are caused, and what was in fig. 5 one object becomes two in this. Thus is shown the distinction between mental and visual objects. There are two mental objects in both 5 and 6; one visual one appears in case 5 and two in case 6.

FIG. 7 represents the white light of the sun streaming through a small hole into a dark room. The light would pass in the line *W. w*. if it were not intercepted by the prism *p*, which shows that it is composed of three kinds of light, each of which is refracted more or less than the rest. The blue is refracted the most, and the red the least. The separation of the three kinds is not in reality as perfect as here represented, and all shades of light act upon the nerves *n*., producing as many kinds of sensation.

FIG. 8. A circle intended to show what colors are complementary to each other.

FIG. 9 is for the purpose of showing why it has been thought that objects appear inverted. The light from *l* acts at 1 in the eye, and the object *l* will seem to be downward. But the light reflected from 1 through the opening comes to eye 2 from above, and of course the object will to the observer 2 seem to be above him.

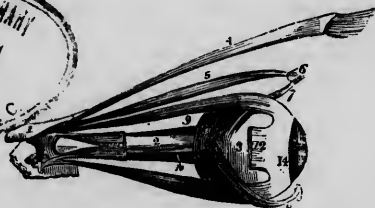
The figures on the left of the page represent objects reflecting purple, blue, yellow, red, and white light, while the upper object does not reflect any light, and therefore appears black. The second is called a mirror, and its apparent color will depend upon the kinds of light falling upon it. The other objects will appear dark except when receiving their own light. Colored objects seem to differ from white rather by what they do not, than by what they do reflect.

HUMAN ANATOMY, PHYSIOLOGY AND HYGIENE.

BY

T. S. LAMBERT, M.D.,

LECTURER ON PHYSIOLOGY AT THE PITTSFIELD INSTITUTE (FOR YOUNG LADIES),
GREENLEAF'S (BROOKLYN), RUTGERS INSTITUTE (NEW-YORK), ETC.



ILLUSTRATED WITH NEARLY THREE HUNDRED WOODCUT AND LITHOGRAPHIC
ENGRAVINGS.

HARTFORD:
BROCKETT, HUTCHINSON & CO.

NEW-YORK: IVISON & PHINNEY.

ROCHESTER: WANZER, BEARDSLEY & CO.;—CINCINNATI: MOORE, ANDERSON & CO.;

DETROIT: KERR AND DOUGHTY;—CHICAGO: S. C. GRIGGS & CO.;—

SPRINGFIELD: HUTCHINSON, CHAFFEE & CO.

1854.

*Deposited in Clerk's Office So. Dist
N. Y. Feb. 3. 1854.
D*

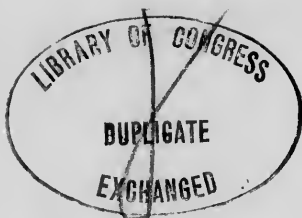
QTA
L223_p
1854

Film 8099 2 rem 5

ENTERED, according to Act of Congress, in the year 1858, by

T. S. LAMBERT,

In the Clerk's Office of the District Court of the United States for the Southern
District of New-York.



JOHN F. TROW,
PRINTER & STEREOTYPHER,
49 Ann-street, N.Y.

TO
MULLER,
BERZELIUS, HENLE, LEIBIG, SCHWAN, TIEDEMAN,
VALENTIN, VOLKMAN, AND WEBER;

TO
AUZOUX, BECLARD, BERAUD, BERARD,
BIOHAT, BONAMY, BOUSINGALT, BOURGERY,
A. COMTE, AU. COMTE, CRUVELHIER, DUGES,
DUMAS, EDWARDS, FLOURENS, HERSCHFELD,
JOURMAIN, JOURDAN, LONJET, LITRE,
MAGENDIE,
OH. ROBIN AND SAPPEY;

TO
ARNOTT, BALY, BOWMAN, CARPENTER, COMBE,
ELLIOTSON, KIRKES, LISTON, M. HALL, OWEN,
PRICHARD, PAGET, QUAIN, SHARPEY,
TODD, WATSON, AND WILSON,
As most distinguished ornaments of their profession and humanity;

TO
JOHN AND CHARLES BELL,
PEREIRA,
ORFILA, COOPER, LAWRENCE, GOOD, HOME, RICHERAND, AND LAENNEC,
(Who though dead yet live,)
As those whose writings have given me the greatest pleasure and much instruction;

AND TO THE
MEDICAL PROFESSION OF THIS COUNTRY,
Whose members, as a body, I love and respect, from too many of whom to particularize I have been the recipient of courtesy, and from whose works and conversation a rich store of knowledge has been gathered, and used with profit in the following pages;

THIS BOOK

Is respectfully Dedicated,

With the intention of rendering honor where it is so richly due, and as the best token of his admiration and indebtedness which can be presented by

THE AUTHOR.

PUBLISHERS' ADVERTISEMENT.

THE inconvenience consequent to a revision of a work is to be regretted. To use a book which is behind the times, or in any considerable degree inferior to what it may be made, is still worse for both scholar and teacher.

The publishers feel assured, that the first appearance of this revised edition will secure it favor, and instantly remove any tendency to complain that may rise in any teacher's mind. A perusal of the book will certainly make it welcome.

The last year or two has been remarkably fruitful in useful and interesting contributions to Biological Science, and in new and beautiful illustrations of it.

The publishers could not therefore either conscientiously, or regarding merely their own interest, hesitate in respect to the course they ought to pursue. When, therefore, it became desirable to make a new set of plates, they determined to cause the work to be rewritten, and illustrated with the most liberal expenditure. They desire to call attention to the following improvements:

1st. The typography and embellishments. The small type of the former edition has been replaced by larger, while the advance of science has allowed even more matter to be condensed within the former number of pages. We now present therefore fewer words, but more and clearer ideas.

2d. The arrangement, generalization and systematization. These are believed to be the best that have ever been exhibited, and show to what a degree of improvement the science of Biology has been advanced.

3d. The Nomenclature. The improvement in this respect is very conspicuous. It may be very positively said, that this, with the order and classification which has been made, will diminish the labor of teacher and pupil not less than half. There is no royal road to learning, yet there is a proper way.

4th. The analysis at the opening of new subjects—the synopsis at the close—and the heads of the pages, are considered important features.

5th. Questions have, at request, been placed at the bottoms of the pages.

6th. A very full glossary and index have been appended.

TABLE OF CONTENTS.

PREFACE.

Objections to study of Physiology removed—Its present state—Extensive application—This work necessarily not a compilation—Arrangement of topics—The best—Its importance—Nomenclature—Confidence in Teachers—Truly scientific works best and easiest for them and Scholars—Modes of using this work—Why written—Thanks for the past—Request for future favors . 23

INTRODUCTION.

Objects of Science—Classification—Relations of Physiology—Its divisions—Relations of Animals to Vegetables—Of Man to both—Subdivision of Human Biology—Anatomy, Physiology, Hygiene—Pathology, Therapeutics, Materia Medica, and Surgery—General and special Anatomy 35

PART I.

GENERAL SURVEY OF MAN.

CHAP. I.—The Mind—To acquire, reflect upon, and communicate knowledge, its duty, pleasure, and profit—The Brain its immediate instrument, with which to feel, think, and cause motion—Brain progressively changing throughout life—Man differs from animals—Education—Illustrations—Important inferences	50
CHAP. II.—To acquire knowledge Sensory Apparatus needed—Touch, Taste, Smell, Seeing, Hearing—Muscular Sense—Tableaux	58
CHAP. III.—For protection, locomotion, handling, and speaking—Skeleton—Muscles and Motory Nerves needed—Tableaux	69
CHAP. IV.—Apparatus of Relation—Tissues, Bony, Cartilaginous, Secretory, Muscular and Nervous—Tableaux	88
CHAP. V.—Tissues must be kept in repair—Useless substance removed—New substance deposited—Tableaux	99
CHAP. VI.—Body must be kept at healthful temperature—Heat produced, circulated, preserved, and removed—Tableaux	101

CHAP. VII.—Water, Food, Oxygen, and Clothing—Circulatory, Respiratory, Digestive, Eliminatory, and Nervous Apparatus necessary—Tableaux	104
CHAP. VIII.—Apparatus of Organic Life—Nervous system necessary—Tissues—Tableaux	125
CHAP. IX.—Apparatus of Relation and Organic Life compose the Physical Man—Their influence upon each other and the Mind—Tableau	129
Review of Part I.	132

PART II.

GENERAL ANATOMY, PHYSIOLOGY, AND HYGIENE.

General Remarks	133
CHAP. I.—Chemical Elements, simple and compound	136
CHAP. II.—Organic Elements, simple and compound	140
CHAP. III.—Tissues and Humors, simple and compound	151
CHAP. IV.—Systems—Simple and compound Organs	189
CHAP. V.—Water—Food—Air—Blood—Heat—Light—Electricity	197
Review of Part II.	213

PART III.

SPECIAL ANATOMY, PHYSIOLOGY, AND HYGIENE.

BOOK I.

APPARATUS OF RELATION.

DIVISION I.

APPARATUS OF MOTION.

CHAP. I.—Skeleton	214
CHAP. II.—Muscular System	272

DIVISION II.

NERVOUS SYSTEM.

CHAP. I.—Nerves	294
CHAP. II.—Spinal Cord	304
CHAP. III.—Encephalon	309
CHAP. IV.—Sympathetic Nerves and Ganglia	328

DIVISION III.

ORGANS OF SENSE.

CHAP. I.—Organs of Touch	334
CHAP. II.—Organs of Taste	337
CHAP. III.—Organs of Smell	339
CHAP. IV.—Organs of Sight	341
CHAP. V.—Organs of Hearing	357
CHAP. VI.—Organs of Muscular Sense	365
CHAP. VII.—Organs of Internal Sense	365

BOOK II.

APPARATUS OF ORGANIC OR VEGETATIVE LIFE.

GENERAL REMARKS.

DIVISION I.

CIRCULATORY APPARATUS.

CHAP. I.—Hearts, Arteries, Capillaries, and Veins	369
CHAP. II.—Causes and Rapidity of Circulation of Blood	382
CHAP. III.—Sympathetic System	385
CHAP. IV.—Closed or Sanguific Glands	387

DIVISION II.

RESPIRATORY APPARATUS.

CHAP. I.—Lungs and Air Passages	391
CHAP. II.—Chest and Respiration	395
CHAP. III.—The Air	400
CHAP. IV.—Speech	408

DIVISION III.

DIGESTIVE APPARATUS.

CHAP. I.—Mouth and Salivary Glands	408
CHAP. II.—Pharynx and Œsophagus	413
CHAP. III.—Stomach	414
CHAP. IV.—Second Stomach, Liver, Pancreas, and Lacteals	424
CHAP. V.—Colon	428

DIVISION IV.

ELIMINATORY APPARATUS.

CHAP. I.—The Lungs	430
CHAP. II.—The Liver	430
CHAP. III.—Second Stomach and Colon	431
CHAP. IV.—Kidneys	431
CHAP. V.—Skin and its Appendages	432
APPENDIX	439
GLOSSARY	446

P R E F A C E.

FOUR prominent objections are sometimes made to the study of Anatomy and Physiology.

First Objection.—"It tends to render the student a Materialist." Nothing, it seems to me, could have a stronger influence in the opposite direction than these same studies. But I propose to introduce two extracts, which will abundantly prove that the notion some people have upon this point is extremely erroneous. One is from the most illustrious of the modern French authors upon physiology, Achille Comte. The other from one of the most eminent of the English Physiologists, and indeed, it may with truth be said of the world, Kirkes. Says Comte: "Physiology, which occupies so honorable a place among the sciences that adorn the genius of the human mind, is a truly philosophical science, when putting God at the head of its researches, it considers in man not merely the mechanism of his organs, but still farther, the *independent action* of an *immaterial* agent, conscious of received impressions. The Physiologist, then, perceives the insufficiency of the entangling explanations with which materialists have abused the human mind, and feels that this machine which moves so perfectly is regulated by some other wisdom than his. As he knows not how to manage this organization, notwithstanding the knowledge he has of its parts, he is constrained to seek for a ruler above all physical causes, and his enlightened reason leads him to a divine intelligence, which harmonizes the action of all things, and

presides with constant and watchful care over the varied and wonderful phenomena of creation. Thus every one has observed that all the ancient and modern philosophers have studied the human organization with the deepest enthusiasm and the strongest emotion. Cicero has described, with all the richness of his style, the forms and beauty of this miraculous being. Fenelon, from the fulness of his Christian soul, most eloquently shows in the perfection of our organs the infinite perfection of our Creator. Bossuet raises himself to the very highest point of philosophical eloquence, when he treats upon this great subject, in his beautiful treatise upon the '*Connaissance de Dieu et de soi-même*,' which seems to have defied both time and the progress of philosophical science * * * * for it exhibits all the truths that can be found in the works of materialists, without presenting any of their wild notions."

Kirkes says: "But while this may be true respecting things of sense, it would require much more and different evidence and arguments to make it probable that the cerebral hemispheres, or any other parts of the brain, are, in any meaning of the term, the *organs* of those parts or powers of the mind which are occupied with things above the senses. The reason or spirit of man, which has knowledge of divine truth, and the conscience, with its natural discernment of right and wrong, cannot be [has not been?] proved to have any connection with the brain. In the complex life we live, they are indeed often exercised upon questions in which the intellect or some other lower mental faculty is also concerned; and in all such cases, men's actions are determined as good or bad, according to the degree in which they are guided by the higher or lower faculties. But the reason and the conscience must be exercised independently of the brain, when they are engaged in the contemplation of things which have not been learned through the senses, or through any intellectual consideration of sensible things. All that a man feels in himself, and can observe in others, of the subjects in which his reason and his conscience are most naturally engaged; of the mode in which these are exercised, and the disturbance to which they are liable, by the perceptions or ideas of sensible things; of the manner and sources of their instruction; of

their natural superiority and supremacy over all the other faculties of the mind; and of his consciousness of responsibility for their use; all teaches him that these faculties are wholly different not in *degree* only, nor as different members of one order, but in *kind and very nature*, from all else of which he is composed; all, if rightly considered, must incline him to receive and hold fast the clearer truth which Revelation has given, of the nature and destinies of the spirit to which these his highest faculties belong.”
—*Kirkes and Paget's Physiology*.

If any thing more appeared necessary to prevent the reiteration of the most untenable of libels upon the medical profession and studies, the abundant and ardent testimony of the most able minds which do, or ever have adorned society, might, and should be heaped up to the very point of perfect conviction. Indeed, there is no department of science, not even Astronomy, which is more a handmaid of piety and morality than Biology. It conclusively proves the truth and fulness of that condensed but complete system of moral Philosophy and Theology the “Lord’s Prayer.”

Second Objection.—“Unprofessional people only injure themselves by thinking of disease.” The reason for the existence of this idea, is that by physicians generally, Anatomy and Physiology have been studied with reference to the cure of disease, and they are therefore thought to be of a professional character. They are not. A knowledge of them is chiefly useful to teach how to exercise and treat the various parts of the body, that they may be in the best possible condition for proper and desirable use. A blacksmith’s muscles may be in health, and yet those of the left arm are not so powerful as those of the right. The organs of speech may be healthy, yet the voice harsher than necessary. The brain may be healthy, yet not equally adapted to every application. The brain of the woodchopper will be well nourished if he eats ham and corn cakes. The student requires other food. The greatest utility of Anatomy, Physiology and Hygiene has seldom been noticed. The more healthy any person is, the more can he apply them. They are not therefore professional but general.

Third Objection.—“There is not time during our short school terms for such studies without neglecting elementary ones.”

What is elementary?—Is it not elementary to produce or increase a relish for acquiring knowledge?

“To please is the *first* step toward instruction.”—*Dr. Nott.*

This is, I believe, too much overlooked. The course frequently pursued induces the child to believe that the acquisition of knowledge is tedious. How can it be otherwise if he is never allowed to taste the pleasures of learning, but is *restricted* to the dry, abstract elements which task the memory without delighting the mind? It is hardly better to excite the child to learn, by stimulating his ambition, by the hopes of reward apart from his study, or by fear of punishment. Well do I remember the picture in the spelling book, of a rugged hill, the crowning temple and the goddess Science, ready to bestow a wreath upon her successful votary; not a flower or fruit to beguile the early steps of the youthful toiler, nor reward of any kind for whoever did not reach the very summit. How utterly false this representation. Teach, oh teach the youthful mind to love to converse with nature's works and enthusiastically to seek for knowledge as one seeks for cool springs to slake his thirst, and thus help to save him from ennui and the seductions of vice and dissipation! No study will be more feasible for such a purpose than that which exhibits the wonders of his own system.

Is the school short or does the parent, guardian or scholar think that a little schooling is all that can be afforded? Then it is so much the more important that the scholar should be excited to go on with his studies during his long vacations. Physiology is especially adapted to effectively convince the student that money cannot be “*spent*” in rightly educating the mind, but is most profitably *invested*. Its argument in favor of acquiring knowledge, is so cogent that it will induce a scholar not only to attend school longer than he otherwise would, but also to give better attention to his studies while there, at the same time it gives him many hints of how to prosecute them most easily and rapidly. It also exhibits so many favorable results of amiability, politeness and affability, and so clearly points out how to cultivate these desirable traits, that every scholar must be at least somewhat influenced, and the whole school managed, therefore, with less vexation and loss of time.

Cannot, also, a scholar learn, in part at least, to read and spell, by studying the sciences?

Fourth Objection.—"Our scholars are not sufficiently advanced." Those who consider Anatomy, Physiology and Hygiene as professional, would naturally suppose that more mental maturity is required for the profitable study of those branches, than for the study of geography. But is not Anatomy the geography of the body? Can a child form a more correct idea of unseen rivers, bays and oceans, mountains, prairies and deserts, than of its own heart or lungs, which can be exactly represented, or the like of which can be seen in any butcher's stall? It is not of course desirable that the young scholar should study the dry details of Anatomy or the great philosophical truths of Physiology, or learned hypotheses and extended experiments. The general student needs only the general principles. These can be exhibited without perplexing verbosity, or occupying much time. As their application is personal, they will naturally secure assiduous attention; an all-important point.

These subjects are also especially adapted for oral instructions, particularly to the young. They can of course appreciate but few of the very many practical truths of Physiology. A more thorough acquaintance with its principles and details must be made when the mind is better prepared to appreciate the rich stores which can be here gathered. As soon, however, as the child is old enough to take care of itself at all, it should begin to learn how to do it properly. Its knowledge should advance as its charge advances. If it is absurd to give a steam engine into the charge of an engineer unacquainted with his business, it is much worse to intrust such a beautiful, delicate and complicated machine as the human body to an engineer perfectly ignorant of its constitution and the proper mode of managing it.

PRESENT STATE OF PHYSIOLOGY.

The rapid advance of chemistry and the perfection of the compound microscope, have developed and simplified Anatomy and Physiology to a truly wonderful degree. Nor are we less indebted

to the philosophical character of the minds which have concentrated their energies to work out the problems, so important to mankind. The last two or three years, in particular, have given us works of a most gratifying character—within that time more than 5000 octavo pages upon the subjects, have been produced in England, France and Germany by the most classic minds. Physiology can no longer be considered an empirical science, but exhibits a completeness and systematic classification, which is exceedingly pleasing to the philosophical eye.

EXTENSIVE APPLICATIONS OF PHYSIOLOGY.

The aspect which Physiology now presents must also be very gratifying to every person; for its practical applications reach to every department of life, and are every day becoming more conspicuous. Its chief use has not always been understood. Many think it is in preserving health and prolonging life. It is vastly more important in teaching how to live and enjoy life, and profit by it. It teaches how to render our homes more delightful, and business more successful and easily accomplished, to increase personal attractions and exert favorable influences upon our fellow-men. It cultivates the heart and improves the mind. Its influence as a study is abundantly shown by the logical writers upon this subject, whose works adorn the scientific literature of the present day. Blackstone no longer stands alone. Dr. Sears has somewhere said that "the study of some books fits the mind to study any others." It is so with subjects, particularly Physiology properly treated. But more than all, Physiology exhibits a relation between the necessities and adaptation of the animal, vegetable and inorganic worlds, which convinces the mind that the universe is a perfect and complete whole. That the weather is governed by laws as uniform as those of the planets; that cold or hot, wet or dry weather, are no more accidents than an eclipse. Thus is the heart led to adore the infinite Creator whose will is the perfect law of all things.

THIS WORK NECESSARILY NOT A COMPILATION.

The recent works on Anatomy and Physiology are mostly professional, and arranged and applied accordingly. Indeed, I am not aware of one which occupies the position proposed for this. It should be complete, scientific, systematic, in accordance with the *present state of Physiology*, and adapted to the understanding and practical wants of the general student. There is therefore no copy to follow, at least but in part. It would also be almost impossible for any person to give particular attention to Physiology for the last few years without having many new ideas suggested to his mind, which it would be worth while to present. Daily experience in teaching general students, would also, of course, suggest arrangements, language, and applications, which would be of great utility. While, therefore, I am proud to refer to those persons mentioned in the dedication, as the sources of the greater part of the ideas presented in this work, I believe it exhibits features sufficiently distinct to give it individuality. In thus claiming some originality, not the least egotism is felt. To add something to the general stock of knowledge, is the duty certainly of every teacher. Who does it, is not to be commended; who does it not, like him who is wanting in any virtue, is to be condemned. Whoever constantly looks down, or through a microscope, may pride himself on his elevation; whoever looks up, or through a telescope, will grow sufficiently modest.

ARRANGEMENT OF TOPICS.

The body is so constituted, that it may be well considered under several arrangements of topics. Sometimes its Anatomy and Physiology are discussed in separate volumes. This is where the professional details require it. Sometimes they are divided into general and special, which are separately treated upon. The body is evidently divisible into two grand classes of Apparatus, one of which is used by the mind directly, and called the apparatus of relation; and the other adapted to keep the body in good condition, and called the apparatus of organic life. Either of these

may be treated upon first, according to the object in view, and either analytically or synthetically. But whatever the plan adopted, the system must be regarded as a whole, and the topics arranged in accordance with the plan and their dependence upon each other. The position of a topic in respect to others, is not accidental. The topics of any department of science are not more perfectly, or naturally connected, than those of Physiology. That lucid writer, Dr. Moore, says:

Every organ of the body is developed according to a specific plan, and for a specific purpose, yet, though perfect in itself as an apparatus adapted to a particular end, it holds relation to other organs and their functions. All the body, united by one life, subserves one soul. Each part harmonizes with the rest, and the purpose of the whole is to furnish a fit medium through which the intelligent spirit may become acquainted, by actual experience and reasonable inference, with the properties of things, and thus supply its innate faculties with appropriate impressions. Ideas are but the images of objects which the mental principle perceives through the bodily senses. The body must, therefore, be fabricated in keeping with the world which it inhabits. Hence we find it subject to the common laws of matter, and only prevented from being resolved into its elements by the life that resides within it.

The body is formed with peculiar reference to two principles—namely, motion and perception: motion administering to the desire of action; perception, to the desire of knowledge. The simple idea of a being placed by Almighty Wisdom, within a body, in order to employ it for intelligence and enjoyment, would appear to require that the organization and functions of that body should be so exactly adjusted to the being using them, and so perfectly co-ordinate with the conditions of external nature, that no disorder might by possibility occur, and no pain be experienced, but rather that every perception should be pleasure, and every action happiness; nor can we fully discern on what our well-being depends, without an insight into our formation, and some knowledge of the place which we occupy in the universe of God.

BEST ARRANGEMENT FOR THE GENERAL STUDENT.

It is always to be kept in mind that every thing is made for a purpose. The purpose is the leading idea. That arrangement which most clearly connects purposes with structure will be the best. "Paley's Theology" has always been so popular, intensely

interesting and instructive, because the course suggested is therein most conspicuously observed. The same general idea has been kept constantly in mind throughout this work. The general object of the work is set forth in this preface. In the introduction the objects of Science, Biology, Anatomy, Physiology, &c., have been exhibited, and a view given of the following portions of the work. Says Arnott, whose works are classic :

“As no man can well understand a subject of which he does not carry a distinct outline in his mind, it is recommended to the reader to study the general *synopsis*, and the *analysis* placed at the heads of the chapters and sections, until the memory be well impressed with them.”—*Arnott's Physics*.

Part I. takes a general survey of man. Says the discriminating and philosophical French anatomist, Cruvelhier :

“Before entering on a detailed description of the numerous organs which compose the human body, it is advisable to present a rapid sketch of the whole. Such general views, instead of embarrassing the mind, at once enlighten and satisfy it, by exhibiting the objects of its research in their true relations, and showing the end to be attained.”

In this part the purpose has been shown and an apparatus constructed accordingly, till we find the whole human system before us.

Part II. treats upon general Anatomy, Physiology and Hygiene. Littré, one of the most illustrious of modern Physiologists, remarks :

“I beg every reader to carefully observe the distinction between general and special Physiology, as, at present, a correct method is not always observed, and ideas very badly systematized are entertained on all sides ; but to have a clear idea of what belongs to general, and what to special, Physiology, is to hold in the hand a conducting thread.”

These remarks are perfectly correct, nor would they be less so if applied to Anatomy. Though the distinction between general and special Anatomy and Physiology, has not been clearly made

in popular works, the present state of science will not permit it to be neglected any longer.

Part III. presents the special Anatomy and Physiology of the system in the anatomical order. Thus the student is caused to view objects from different points, obtains a more correct idea of them, and becomes more deeply interested than if he should take but a single view.

NOMENCLATURE.

The present state of Anatomy and Physiology allows and has caused some very decided improvements in anatomical nomenclature. Every teacher and scholar will be glad of this. Technical terms are of course needed, for every name is a technicality. By the assistance of chemistry and the microscope, analogies and similarities in structure and use are found to exist between parts, which enable us to give generic and specific names, and which greatly facilitate the acquisition of knowledge. Whenever a name will express or refer to a use, it is better than a name dependent on position or some fancied resemblance to something out of the body. It is also exceedingly important that the term should be always used in the same defined sense. A variety of terms with the same meaning, is equally objectionable. A full glossary explains all terms used, gives their synonymes and relieves of difficulty on either point.

CONFIDENCE IN TEACHERS.

The pleasant acquaintance I have with many teachers gives me confidence, in submitting this work to them and others, that it will not be condemned because it does not follow in all respects the past, or repeat its errors. I wish them to examine it, read it, use it, and judge of it for themselves, unbiased by friendship or the opinions of any one, but solely with reference to the good of their scholars. It seems to me that truly scientific works are best and easiest for both teacher and scholar. Instead of being more incomprehensible and difficult, it seems to me they are clearer, and

more readily stored in the memory. If a work be a connected whole, a teacher can easily ask and answer questions upon any of its topics. He will find there is a why and wherefore for every part, book, division, chapter, section, and paragraph being as it is; and no one could, I believe, be dropped, or have its place changed, without some disadvantage. It is believed that he will find the arrangement, nomenclature, and language used herein diminishes the labor of acquiring physiological knowledge fully one-half. Is it replied, "There is no royal road to learning?" Are not all our schools, academies, and colleges for the purpose of pointing us to shorter, easier paths than, unassisted, we could find?"

MODE OF USING THE WORK.

Before commencing this work, the student should, if it is convenient, read the First Book of this series. It is small, but not on that account contemptible. It familiarly illustrates many ideas, and prepares the mind for advanced views of physiological science. Two books are sufficient for a class—one will answer. During the recitation hours of a week it can be read through. In that case, recitations would then be commenced with the Introduction of this book. This book is, however, complete. Part I. was introduced partly to avoid the necessity of using the First Book. If the scholar begins with this, it is recommended that he read the Introduction, and Parts I. and II., during the recitation hour, being asked some general questions. Let him commence recitation at Part III., and go on through the book, always going back to any references made. When he reviews the entire work, the Introduction and Parts I. and II. may be dwelt upon as the teacher shall think advisable. If the time be very short, the scholar may be enjoined to read over at home the portions anterior to Part III., upon which his recitation may commence the second or third day.

WHY THIS WORK WAS WRITTEN.

When the first edition of this work was written three objects were in view—to obtain a compensation, to gain the esteem of the

public, to benefit the community. In the revision the same motives have, doubtless, had their influence. There are, however, others of greater moment. The success of the work was then problematical, it is now historical. A degree of responsibility is now felt that could not be then. The ideas expressed will certainly influence the minds of thousands. It was then doubtful how much might be ventured by either author or publisher. It is now a duty to exhibit physiological science in all its beauty, accuracy, and utility. There is now an obligation to teachers to facilitate their labors, and to render them pleasant to the highest possible degree. I regret exceedingly that I am not better able to accomplish the task undertaken. The subject is worthy of the eloquence of the ablest pens. Such an one I do not control. The matter I vouch for the excellence of: I wish the manner was better. Those who find in it any thing to satisfy or gratify them will, it is hoped, consider that our best friends have faults, on account of which many times we love them the better, as they do not seem to be more perfect than ourselves. For the favors so generally shown to me heretofore I wish to tender my sincere thanks. They will be requited with pleasure in any way which lies in my power. Towards this revision I ask that the same good will may be shown as was bestowed upon its predecessor; and if any service can be rendered in return, it will be a source of gratification to

THE AUTHOR.

HUMAN ANATOMY, PHYSIOLOGY AND HYGIENE.

INTRODUCTION.

Objects of Science—Classification—Relations of Physiology—Its Divisions—Relations of Animals to Vegetables—Of Man to both—Subdivision of Human Biology—Anatomy, Physiology, Hygiene—Pathology, Therapeutics, Materia Medica, and Surgery—General and Special Anatomy.

1. *The Objects of Science* may be embraced under two heads, Mind and Matter.

2. *Matter exhibits itself* as organized and unorganized.

3. *Three Grand Departments of Science* may be made: 1st, Mental Science; 2d, Biology; 3d, Cosmology.*

4. *Mental Science* has naturally three divisions:—1st. Theology—which considers the relations of man to his Creator. It is the highest and most profitable which can absorb the attention of man. Its perfection depends upon Revelation. 2d. Sociology—which considers the relations

* This classification is not intended to be rigid and inflexible. This is not the place to enter upon a detailed classification of the departments of science. What is done, serves its purpose in this Work. It is not my intention to enter upon any debate.

Have you read the preface? Give a synopsis of it? Give an analysis of the introduction? How many and what departments of science may be made? How many and what divisions of mental science?

 Biology defined—Man not an animal.

of men to each other. It depends for its development upon Revelation and upon history to a great degree, but in part upon the departments below it. 3d. Psychology.—This considers the relations of man to himself, the nature and powers of his mind, and the mode of developing it. It somewhat depends upon the departments above, but chiefly relies upon those below itself.

By some, Psychology has been classed as a department of Biology; but though the character of the mental phenomena will depend very much upon the body with which they are associated, they are not to be accounted as the offspring of the material combinations alone.

5. *Biology*, as the word signifies, is a discourse upon every thing exhibiting life, and may be divided into Vegetable (Botany), Animal (Zoology), and Human.

Formerly, three kingdoms were made—viz., mineral, vegetable, and animal. Man was ranked with animals; but man is no more an animal than an animal is a vegetable. The vegetable exhibits the processes of nutrition, development, and reproduction, and consequently life, to which they are essential. The same operations take place in all parts of an animal, however, which is in these respects merely a vegetable.

Illus.—Sometimes a person loses all power over and feeling in a limb, but yet it lives years; it is, however, a mere vegetative life.

In the animal, two other things are noticable as hinted in the illustration; the power of motion and the possession of sensibility or capability if not of feeling, of having motion produced by the action of a proper cause. The animal then embraces the vegetable; so does man embrace both the animal and vegetable characteristics, but he possesses something infinitely superior. There is nothing I shall insist on more. If a person choose to call that mind which the animal exhibits, I will fall back upon soul. I care not for the word, but I cannot consent to any mixing of the ideas; I call all that the animal exhibits instinctive, and the same in man by the same name. By mind, I mean that which distinguishes

Is the mind the result of organization? How many kinds of biology? Any other name for them? Is man an animal? What processes are essential to life? Are they exhibited in the vegetable? What else is characteristic of an animal?

Human Biology—Its Relations.

man; the action of which is felt as distinctly as that of the light which shines in at the eye. It does not seem possible, nor do I believe, that I who write these lines am like yonder dog, except in degree. Who reads them, cannot be.

6. *Human Biology* is a complete discourse upon the human system. The relations of this department of science to those above and below it, will be perceived by reflecting, that through the body the mind acts upon, and is acted upon by, the world—that the food of the system is drawn from the animal and vegetable worlds—that the system exhibits the characteristics of animal and vegetable life,* and is constantly influenced for good or harm by the ever surrounding objects of nature.

7. *The Relations of Human Biology* may be best exhibited by the following tableau :

MIND ; BODY ;—WORLD ;—BODY ; MIND.

Mind acts upon mind through two bodies and the world.

Strictly speaking, however, mind only acts upon and is acted upon by itself and its body ; but the body can never act favorably upon the mind, except a proper state of the surrounding world exists. This state is affected by the body of every person, and that body again by his mind ; therefore, to best use and enjoy our own minds and bodies, and those of other persons, and also the world, harmonious relations must exist among them all. As those which exist between each man's mind and body and the world, are most important to him, so are they most under his control ; but as every man must be very much affected by every other of his fellow-men, so is he necessarily and correspondingly interested in society.

* Hence often illustrations can be drawn from vegetables and animals, where the functions are more isolated and easily exhibited than in man.

What is Human Biology? How are its relations perceived? Through what does mind act upon mind? What effect does the world have upon the mind? Who are interested in society?

 Animal Biology—Its relation to Human.

8. *To render the relations of the Mind, Body and World most harmonious*, three things must be understood; how to properly

EDUCATE THE	EXERCISE THE	ARRANGE THE
MIND.	BODY	WORLD.

These things correspond to the three grand departments of science :

MENTAL SCIENCE;—BIOLOGY;—COSMOLOGY.

As all persons must act on the world, it cannot be arranged by one alone. It matters not, if it be properly arranged. Then it can be used, enjoyed, and in the best sense of the term *owned* by the educated mind, if its body be properly exercised. As well pay taxes on the moon in order to enjoy its shining, as on a neighboring fountain, flower garden, finely-proportioned house, or aught else adapted to please an educated mind.

9. *Animal Biology* describes animals. They are distinguished from vegetables, by exhibiting motion and sensation, and from man, by not exhibiting any sense of right or wrong, any desire to obtain knowledge, or any mental progress through life; and by having a history which terminates with each individual, while the history of man is the history of the race, and has not reached its conclusion. Many other things distinctly human might be mentioned.

10. *The relation of Animal to Human Biology* consists not so much in the influences which animals exert upon man, the comforts they furnish, and the necessities they serve, as in the fact, that a large number of physical operations exhibited by man, are of a purely animal character. They are plainly exhibited by animals, and can then be made out in the human body.

What must be understood in order to render the mind, body and world harmonious? What three departments of science are named? What is Animal Biology? How are animals distinguished from vegetables? How from man? In what does the relation of Animal to Human Biology consist?

Vegetable Biology—Relations to Human Biology further divided.

11. *Vegetable Biology* describes vegetable life. The characteristics of this are nutrition, development and reproduction, and nothing more. The distinction between animal and vegetable life is, therefore, very clear. Animal life always embraces vegetable life, and cannot exist alone. Vegetable life may be independent.

12. *The relations of Vegetable to Human Biology* are of a very prominent character. Not so much because, either directly or indirectly, our food must come from the vegetable kingdom, or because so many of the beauties of the world are produced by its vegetation, as because many of the processes taking place in the human body are purely vegetative.

The cells or corpuscles of the blood I suppose to be vegetable as truly as the cell called the yeast plant. Their office is doubtless vegetative, viz., the preparation of substance for use (see p.184). The egg is also a vegetable, till, by the action of the heat, its components have undergone those changes and formations which permit motion and sensation to be manifested. A thousand things in the human system, otherwise obscure, become like daylight when the instruction gained from the vegetable world is brought to bear upon the knotty points. See Prof. Draper's admirable work upon "The Circulation in Plants."

13. *Biology is also divided* into Comparative and Theological, or Philosophical.

The theological is also called Natural Theology, though this term is generally used in a more generic sense, and gathers its illustrations of the goodness, wisdom, and power of God from every department of nature.

14. *Comparative Biology* compares the various parts of man, animals, and plants, pointing out resemblances or dissimilarities, and drawing instructing or pleasing inferences.

What are characteristics of vegetable life? Compare animal and vegetable life? Why relations of Vegetable to Human Biology important? What is Theological Biology? How distinguished from Natural Biology? What is Comparative Biology?

Theological Biology—Cosmology—Its Relations.

15. *Theological Biology* endeavors to lead the mind to form some correct conceptions of the character of the Deity, by conspicuously exhibiting the most remarkable beauties and perfections to be found in living things, more especially those adaptations which most impressively show design.

16. *Cosmology* completely describes the inorganic world. It embraces Chemistry, Natural Philosophy, Astronomy, Meteorology, Mineralogy, Geology, and Geography.

17. *The relations of Cosmology to Biology* are exceedingly important. Not only do vegetables derive their sustenance from the earth; and man not only breathes the air, and drinks the water, but his eye is acted upon by light; his ear by the waves of air; his skin by the genial warmth of spring or the chill blasts of winter; his foot by the ground; his sense of smell regaled by odors; and his taste by savors. Every one of the departments of Cosmology may be made his useful servant, and with the general principles of all of them he should be perfectly familiar.

It should be observed that I say general principles, not details. Here also it may be said that to understand the general principles of any of the departments of science which have been mentioned, an acquaintance with the principles of mathematics and languages will be essential. These may be, therefore, as they are called, elementary or fundamental; but it should also be remembered that they are only means.

18. *The relations of all the departments of science* will be best exhibited by the following tableau:*

* I somewhat hesitated in writing down OBSERVATION even as an elementary branch of science. There is so little attention paid to teaching a child to observe, and how to observe, that it was doubtful if my idea of its importance was not exaggerated; but

What does Cosmology describe? What embrace? State some of the ways in which man is acted upon by the properties of the world? With what should every person be acquainted? Why?

Tableau of relations of Departments of Science.

TABLEAU:

MENTAL SCIENCE	{	THEOLOGY; (Revelation).			
		SOCIOLOGY; (History).			
		PSYCHOLOGY.			
BIOLOGY	--	{	HUMAN - - - -	{	LITERARY
			ANIMAL.		PROFESSIONAL
			VEGETABLE.		
					{ ANATOMY.
					PHYSIOLOGY.
					HYGIENE.
					PATHOLOGY.
					THERAPEUTICS.
					MATERIA MEDICA.
					SURGERY.
COSMOLOGY	-	{	CHEMISTRY.		
			NATURAL PHILOSOPHY.		
			ASTRONOMY.		
			METEOROLOGY.		
			GEOLOGY.		
			GEOGRAPHY.		
			Mathematics.		
			Language—Observation.		

I may be permitted to apologize for the simplicity of the above arrangement. It has been, however, of great advantage to my own mind, and seems to exhibit the natural order of dependence of one science upon another. The idea must not be conceived that a person can perfect himself in one without any knowledge of the rest. A person can obtain quite a good knowledge of an inferior without any, of a superior; but it would be quite ridiculous to endeavour to acquire a perfect knowledge of a superior without any, of those below it. The true idea is, that a general knowledge of all is necessary in order to have a perfect knowledge of any. The general and practical principles of all can and ought to be learned by every boy and girl throughout our land. Above all, let not languages and mathematics be despised as not practical. As well might the blacksmith despise his bellows—because not they, but the coal, heats his iron, and it is hard work to “blow” them.

really it seems to me one of the most important things in a child's or youth's education. There is a systematic mode of observing which assists remarkably in disciplining the mind. A child can and does observe before it is old enough to read; and all through life a person can learn more by observation than in any other way. It is also the natural and most pleasant way of being instructed. Some part of every day

What are the divisions of Mental Science? What of Biology? What of Cosmology? What is said of Observation by the Author? What by Parker, and quoted? What by Moore? Can a knowledge of any branch be obtained alone? What is the true idea?

Human Biology subdivided—Quotation from Moore.

19. *Human Biology is subdivided into literary and professional departments.*

20. *The literary department embraces Anatomy, Physiology, and Hygiene.*

it seems to me, a student should be exercised in such a way as to develop most advantageously and scientifically an aptness for observation.

Says Parker, in the opening clause of his "Aids: "

"To acquire ideas, it is necessary to cultivate habits of observation; to use the eyes [and all the organs of sense], not only in noticing entire objects, but also their different parts; to consider their quality, operations, uses, and effects, together with their relation to other things. Thus employed, the mind acquires materials for its own operations, and thoughts and ideas arise as it were spontaneously."

I cannot forbear adding a long quotation from "Body and Mind," one of the works of Dr. George Moore (Harper & Brothers), from which I shall often take excellent passages. I wish the works themselves were in the hands of every teacher and reading person:

"Whatever suggests the appearance of living action is most agreeable and enduring in the mind. Our knowledge is intended to be associated with our feelings. Hence it is difficult to teach children the rudiments of language without associating even the forms of letters with their ideas of actual life and motion. Every lesson should be on objects. God's works and man's are what we have to learn, and he whose mind dwells in books without familiarity with things, lives in a dream; his reason is unsettled, he has no true faith, for the world of true faith is a true world full of great facts of a palpable kind, which none but madmen would dispute about. Hence the importance of familiarity with physical science, and the positive operations of mind on mind, and the grand events of providence and history, to the formation of a true philosopher.

"Natural objects seen in natural order, are far better remembered than what is merely heard; and yet, if we properly attend, we generally retain the fact stated in a lecture much more distinctly than those related in a book, which we only curiously read; and this seems to arise from our imaginations being more called into action to realize what we hear, than what is merely presented to us in printed works; for spoken language is natural, and excites our nerves sympathetically, according to intonation of voice, but letters are altogether artificial and conventional, requiring an effort to interpret them; so that, to enjoy books thoroughly, it is necessary that the reader should be quite habituated to reading, and accustomed to constrain his mind to idealize. The prolonged attention to minute objects, as in print, is itself disturbing to the faculties, and requires a long labor to overcome its evil effects. Indeed, it is not improbable that great readers are invariably awkward and untoward men, because the habits of their minds are unnatural, that is, without proper sympathies, and some of their faculties benumbed by too constant a use of their eyes on print, instead of human faces, and the many eloquent objects of nature. The unnaturalness of reading is seen in the vast difficulty experienced in educating by this means, through the medium of books, those persons who have not been accustomed to apply the eye to the discrimination of minute objects. Even the children of such persons from hereditary formation are scarcely able, under the strongest motive, sufficiently to fix their attention on letters to learn them. This difficulty is especially observed among wandering tribes. Hence we learn the wisdom of that command, *'Go ye into all the world and preach.*

"Though the world of flowers and perfume is not created so much for man as for

How is Human Biology subdivided?

 Subdivisions of Literary and Professional Departments of Human Biology.

21. *The professional department embraces* Pathology, Therapeutics, Materia Medica, and Surgery.

The above division has been made, because, though Anatomy and Physiology may be studied and used for professional purposes, they no more belong to the medical profession than Chemistry or Mathematics; Chemistry is nearer to Medicine than Mathematics; Anatomy is one step nearer than Chemistry; but the profession is not reached till after two steps more, and Pathology is begun;—Anatomy, Physiology, and Hygiene should, therefore, be taught in schools of general science as much as Natural Philosophy, and for the same purpose as well as others, viz., to fit a person for any situation in life or any profession. It would not have been advisable to enter upon a minute subdivision of the professional department. The generic heads only are given.

22. *Anatomy describes* the color, size, form, surface, density, weight, composition, number, position, connections, and safeguards of the body and its various parts.

23. *Physiology describes* the objects, purposes, functions, uses, and properties of the body and its parts, and the mode and effect of action.

24. *Hygiene describes* the means which can and should be used to preserve a healthful state not only, but such as will best allow every proper desirable action.

25. *Pathology describes* the state produced by disease. Comparative Pathology compares the state in disease with that in health, and the effects of disease in various animals.

26. *Therapeutics treat* upon the use of curatives.

beings generally disregarded by him, yet he cannot scrutinize a blossom without improving his sense of beauty, or be influenced by a color without some corresponding change in the state of his affections. Let not this observation be thought a refinement of fancy; it is a fact that man cannot be intellectually acquainted with natural beauty, without acquiring a clearness of spirit and serenity of heart unknown to ignorance; for thus, in truth, he becomes familiar with the mind of God."

What does the literary department of Human Biology embrace? What the professional? What is said of the study of Anatomy as a professional study? What does Anatomy describe? Physiology? Hygiene? Pathology? Therapeutics?

 Anatomy divided—Special Anatomy defined?

27. *Materia Medica* treats upon the medicinal character of all substances, and their compounds.*

28. *Surgery* treats upon accidents and external diseases, manual operations and applications.

Human Biology practical to the general student is chiefly found in the literary departments, but occasionally ideas and illustrations taken from the professional departments will be both interesting and profitable.

Illus.—How to stop the flow of blood. How to restore animation in case of drowning—suffocation—choking, &c. How to treat persons who have been poisoned, struck by lightning, etc.

29. *Anatomy* is divided into special or descriptive, and general or textural. Each may be considered analytically and synthetically.

30. *Special Anatomy* treats upon those parts of the body which have a special purpose, and differ, in some respects, from all other parts. Analytically, it considers the body as a whole, its classes and kinds of apparatus, and the organs which compose them, resolving the organs into the

* The thoroughly educated, scientific professional practitioner is, therefore, limited in the use of remedies only by the universe and his own judgment. His mind embraces a knowledge of the medical adaptation of every thing, so far as human knowledge has yet advanced. To him there is no new system, or exclusive one—only advances of knowledge. His system is always one and the same, viz. the use of any thing, in any way, which will, in his judgment, cure. This is the doctrine of all our scientific physicians and professors, and is the only correct one, and will meet the approbation of common sense every where. If this were understood, it would save people from a host of impositions. They think that scientific medical men are taught, and learn the nature of only a few remedies, and are prejudiced in favor of them; while every truly zealous and scientific man is constantly anxious to enlarge the boundaries of his medicinal knowledge. For more on this point see article on 'Quackery' in Appendix.

Upon what does *Materia Medica* treat? Give substance of note? *Surgery* treats upon what? How is *Anatomy* divided? What does *Special Anatomy* discuss? Analytically how does it treat upon the body?

 General Anatomy defined—Other divisions of Anatomy.

systems of general Anatomy. Synthetically, it composes the organs from the systems, groups the organs into kinds of apparatus, those into classes, from which it produces the body.

31. *General Anatomy treats* upon those parts which exist generally, or are common to several organs. Analytically, it considers the systems from which the organs are formed; the tissues, compound and simple, and humors; their compound and simple organic elements, and the compound and simple chemical elements which form them. Synthetically, it considers the simple and compound chemicals which enter into the composition of simple and compound organic elements. It compounds from these the humors and tissues, simple and compound; the whole of any one of which in the body, is called a system.

32. *Systems* are therefore the connecting links between general and special Anatomy. Thus united, these exhibit a complete scale, through which, by regular, easy, and pleasant steps, we may ascend or descend: finding at one extreme the minute chemical elements—the simplest works of the Creator; at the other, the complete Human System the most complex and beautiful of all mechanism, and the most admirable proof of the existence, power, wisdom, and goodness of the Deity.

33. *Anatomy is also divided* into Physiological, which treats of the healthy; Pathological, which treats of the diseased system; Artistic, which treats of external appearances, attitudes, expressions, &c.; Comparative, Theological, and Philosophical.

34. *Physiology is divided* like Anatomy, and may be considered either analytically or synthetically.

How synthetically? Upon what does General Anatomy treat? Analytically, it considers what and how? Synthetically? What are systems? What other divisions of Anatomy are or may be made?

Special and General Physiology and Hygiene.

35. *Special Physiology* analytically treats upon the general uses of the body, the functions of classes and kinds of apparatus, and the uses of the organs. Synthetically the order is reversed.

36. *General Physiology* treats analytically upon the properties of systems, tissues, humors, anatomical and chemical elements. Synthetically, upon the same things in the reverse order.

The correlation of Anatomy and Physiology in all their divisions has been fully exhibited. Says the learned Littré, "One without the other is nothing; Physiology is only Anatomy put in action." But the idea of the object to be obtained must of course precede in the mind the idea of the means to be used in obtaining it. Anatomy must, therefore, in the natural order of ideas, be secondary to Physiology. Often, however, a knowledge of the anatomy of a part reveals its physiology. Anatomy could be carried to a high degree of perfection without any assistance from Physiology; but it could hardly advance at all without Anatomy. Alone, however, Anatomy would be dry and lifeless as a skeleton. Physiology clothes it with attractions, and gives life and action to every part.

37. *Hygiene is divided* into Mental and Physical.

38. *Mental Hygiene treats* upon mental influences and action, or exercises best adapted to preserve health, of mind and body, and a state best adapted to gain any proper desirable object.

39. *Physical Hygiene is divided* into organic and inorganic.

40. *Organic Hygiene*, like Anatomy, is divided into special and general; and treats upon the means, and mode, and degree of exercise or action, which is to be used or permitted for preserving the health of all parts of the body, and such

How is Physiology divided? Define Special Physiology? Define General Physiology? What relations have Anatomy and Physiology to each other? How is Hygiene divided? Upon what does Mental Hygiene treat? How is Physical Hygiene divided? How Organic?

Hygienic Laws—Correlation of Anatomy, Physiology, and Hygiene.

a state of them as is best adapted for gaining a proper and desirable object.

41. *Inorganic Hygiene* treats upon the influences of the external world upon the body, and the means to be used for causing the action of those which are healthful, and preventing that of those which are deleterious.

42. *The laws of Hygiene* are universal and personal. The universal are those by which all should be governed. Personal laws apply to individuals only.

The universal laws may be exhibited in a work like this; like principles, they are few, easily learned, remembered, and applied. The personal laws can only be known and applied by study in the case of each person, and this with the great number of different circumstances in which during life every one is placed, makes it absolutely necessary that each individual should be familiar with the general principles of Hygiene, and the why and wherefore of them.

43. *The laws of Hygiene are drawn from four sources*—Anatomy, Physiology, Chemistry, and Experience. The first three are legitimate and reliable—the last is very liable to be erroneous, biased, and prejudiced, and is to be received with great caution, especially if it be obtained from an unprofessional source.

Chemistry exhibits the character of food, air, and water, and thus enables Hygiene to draw important inferences; but Anatomy, especially Chemical Anatomy, and Physiology, are the chief sources of Hygienic laws; and, if these departments were perfectly understood, that of Hygiene would be almost complete. Indeed, in one sense, Hygiene is the practical inferences drawn from Anatomy and Physiology.

44. *The correlation between Anatomy, Physiology, and Hygiene* is very conspicuous. To study them *step by step*

Upon what does inorganic Hygiene treat? Are laws of Hygiene equally applicable to all? How personal laws learned? Whence laws of Hygiene drawn? What source should be distrusted? Why?

Definition of Hygiene—Divisions to follow.

together, is not only proper, but absolutely necessary for the greatest profit, as well as interest of the student.

Whenever an anatomical, or a physiological, or chemical fact exhibits a Hygienic law, the mind should be at once called to it. Then will it be powerfully felt, and not only itself easily remembered, but also the Anatomy and Physiology with which it is associated, and upon which it is dependent. Thus is Hygiene the ripe and satisfying fruit which makes us remember whence it came and how it grew.

45. *Hygiene is, therefore*, that department of science which treats not only upon the means of preserving mental and physical health, but also upon the means of best *using and enjoying* the mind, body, and the world; and is useful still more to those who possess health, than to those who have it not.

With this idea of the importance of our subject in mind, I will endeavor to present the Anatomy, Physiology, and Hygiene of the human system in the best manner I can; and will,

46. First, take a general survey of Man; his mind and body, and their parts; their purposes, functions, uses, and properties; and make inferences.

47. Second, treat upon the Chemical and Anatomical elements, tissues, humors, systems, and their properties, viz.: General Anatomy and Physiology, and the Hygienic inferences.

48. Third, treat upon the organs, kinds, and classes of apparatus—their uses, functions, and purposes, viz.: Special Anatomy and Physiology,—and upon the Hygienic inferences to be drawn.

How should the literary departments of Biology be studied? When should any Hygienic law be exhibited? What will be the result? What is Hygiene, properly speaking? How many divisions are to be followed in this work? What is treated in the First? Second? Third? Give a synopsis of the Introduction?

PART I.

GENERAL SURVEY OF MAN.

“What a piece of work is a man! How noble in reason! how infinite in faculties! in form and moving how express and admirable! in action how like an angel! in apprehension how like a god! the beauty of the world! the paragon of animals.”

SHAKESPEARE.

CHAPTER I.

The Mind—To acquire, reflect upon, and communicate knowledge, its duty, pleasure, and profit—The Brain its immediate instrument, with which to feel, think, and cause motion—Brain progressively changing throughout life—Man differs from Animals—Education—Illustrations—Important Inferences.

The Mind and Brain.

Man may be distinguished from other animals by the form and other peculiarities of his physical system. This, however, is merely a machine; without something to use it, it can do nothing. The perfect idiot is more helpless than the lamb—fears no danger, cannot ward it off, and becomes a prey even to the natural elements. But when the action of the body is properly directed, the feeblest man is able to entangle the strength of the king of the forest, to capture the leviathan, outstrip the fleetness of the swiftest beasts, and bend the elements themselves to his wishes. As then, any machine has necessarily a certain form, &c., that it may fulfil certain duties, so the body has necessarily its form and peculiarities, that certain objects may be accomplished by its use. A man is not, therefore, a man on account of his form.

49. *Man is properly distinguished* from animals, exalted above them, and made master of creation by the possession of what is called MIND.

What is the subject of Part I.? Repeat Shakespeare's apostrophe in respect to man. What are the topics of the first chapter of Part I.? How may man be distinguished from animals? How is man properly distinguished?

The existence in man of a mind, superior in any thing except degree of development to what is found in animals, is denied by some. But if we compare the skeletons of those animals which approach most nearly to man in form and many actions—as that of the Chimpanzee (fig. 3) with the human skeleton (fig. 2); it is easy to see that one will require a mind to use it in every respect to which it is adapted, while the other can have but limited uses, and might easily be controlled by an undeviating instinct. The inability to stand firmly, in an erect posture, would unfit the whole of the simia tribe for the manifestations of mental power, while their long arms are not more unseemly than they would be inconvenient to the purposes to which man would desire to apply them. The hand alone would be sufficient to prove, not merely the superiority of that which distinguishes man, but also its distinctive character. Indeed, some philosophers have argued, mistaking cause for effect, that the use of the hand developed the instinct till it became intellect;

Fig. 2.

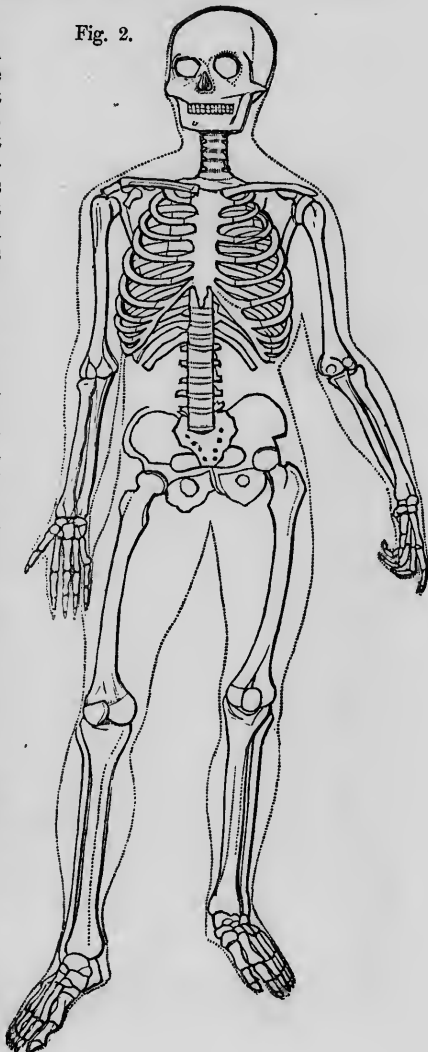
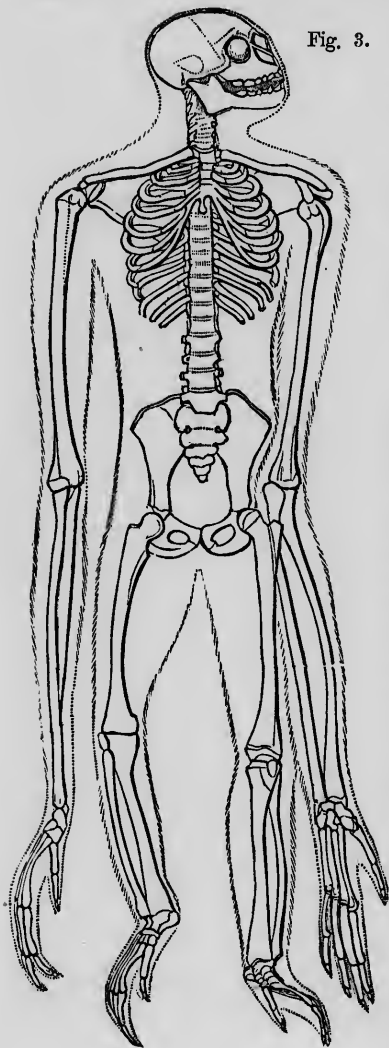


Fig. 3.



and because the thumb is the most distinguishing feature of the hand, some have gone so far as to argue that the possession of the mind depends upon the possession of the thumb. However wise such writers were in respect to many subjects, those ideas may be justly characterized as foolish, nor should the arguments they advanced receive any more consideration because those who propounded them were learned. It is strange that such men should advance such ideas as that mind is the product of matter, or dependent on the thumb. As well might it be said that the musical performer or composer is dependent upon the possession of an instrument from which, with skilful touch, he elicits delightful melodies. Indeed, the skeleton and apparatus of an animal may well be compared to one of those mechanical musical instruments, which, when wound up, instinctively turns off an unvarying repetition of sounds, while the framework of man, and its motory appendages, combines all the harmonies of the entire scale, and needs but the control of the magic mind to compound its actions and gain any end.

 Effects of Mind upon the Body—How Mind is developed.

“What is it that so skilfully touches this instrument? What is it that enjoys as well as actuates, receives as well as communicates, through this inscrutable organization? It is, as we have said, the soul or spirit, without which this body were more unmeaning than a statue, and only fit, as it would tend, to decay. It is the soul which animates the features and causes them to present a living picture of each passion, so that the inmost agitations of the heart become visible in a moment, and the wish that would seek concealment betrays its presence and its power, in the vivid eye, while the blood kindles into crimson with a thought that burns along the brow. It is this which diffuses a sweet serenity and rest upon the visage, when our feelings are tranquillized, and our thoughts abide with heaven, like ocean in a calm, reflecting the peaceful glories of the cloudless skies. This indwelling spirit of power blends our features into unison and harmony, and awakes ‘the music breathing from the face,’ when in association with those we love, and heart answering to heart, we live in sympathy, while memory and hope repose alike in smiles upon the bosom of enjoyment. It is a flame from heaven purer than Promethean fire, that vivifies and energizes the breathing form. It is an immaterial essence, a being, which wills when we act, attends when we perceive, looks into the past when we reflect, and, not content with the present, shoots with all its aims and all its hopes into the futurity that is for ever dawning upon it.”—*Dr. Moore.*

50. *The Mind may be defined* as that which thinks, feels, and causes voluntary action, and belongs only to man.

51. *To develope and cultivate* all the powers of the mind to the highest possible degree, is the great object of education.

52. *The Mind is developed* by properly acquiring, reflecting upon, and communicating knowledge, and to develope it is the assiduous work of a lifetime.

53. *To properly acquire, reflect upon, and communicate knowledge*, is not only the duty and profit, but the highest pleasure of the mind, and not less advantageous to the body

According to Moore, what is the effect of the soul upon the body? Will, then, a noble soul cause the body to exhibit beauty or ugliness? What does Moore describe the soul to be? How does the Author define the mind?

 The Brain the immediate instrument of the Mind.

than the mind; while inactivity, or improper activity, will directly or indirectly produce mental unhappiness and physical inability.

It is not therefore to be regretted that education is the work of a lifetime. Says Moore:

"Each stage of life prepares for succeeding stages, and each, when properly conducted, enjoys a new happiness, without necessarily losing the peculiar enjoyments of the past; for our existence is enlarged by addition rather than expansion; and the man of years may still delight with childlike freshness in the objects of creation, not merely from their novelty or fitness to his senses, but also because they all convey a fulness of meaning which experience has taught him partly to interpret."

54. *That the Mind may gather knowledge*, it must receive influences from the world. As a medium of intercourse and interchange of influences with the world it requires an apparatus which shall be constantly subject to its control and intimately associated with it.

55. *The Brain* is such an apparatus, and is the immediate instrument of the mind. The brain is a collection of nervous organs, beautifully and very delicately constituted, occupying the central part of the head, and about two-thirds of its size.

The brain is therefore the political capital, where the enthroned mind receives reports from every part of the body, and through it from the world without—and from whence it causes its mandates to be executed within and around the body. How mind and brain are associated, or how they act upon each other no person can yet tell. So much do the manifestations of the mind depend upon the state of the brain, that some have too hastily concluded, that mind was only the result of the action of certain parts of the body. On the other hand, others have thought that the mind uses the body only as a means of intercourse with the world, but that the mind

What is said of acquiring, reflecting upon, and communicating knowledge? What does Moore say of each stage of life? What is necessary in order that the mind may gather knowledge? What is the brain? What have several persons concluded?

 Proofs that the Brain is the immediate instrument of the Mind.

can think independently of the brain. This may sometimes be the case. There is no proof of it. Every argument shows that, for all practical purposes, we may regard the activity of the mind as always producing, produced by, or associated with, exercise of the brain.

56. *That the brain is the immediate instrument of the mind in feeling and causing motion, is proved by the fact*

FIG. 4.

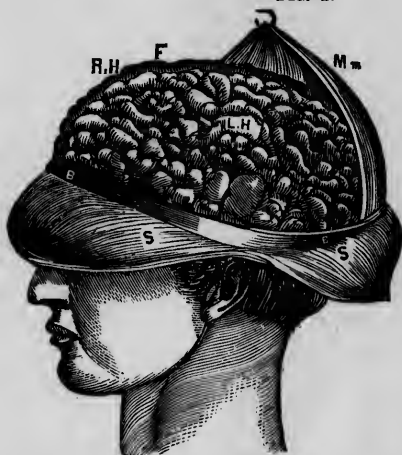


FIG. 4.

S represents the scalp, next to which is seen the skull or cranium (B.E.). M.m., a part of the membrane lining the skull and covering the brain. L.H., left hemisphere of the brain. R.H., a small portion of the right hemisphere seen beyond. F, the deep fissure in which the falx is situated.

that the channels—the nerves—(Fig. 5) by which the world acts, converge to the brain, and those through which the world is acted upon diverge from the brain.

57. *That the brain is used by the mind when thinking, is proved by the increased activity with which the blood then circulates through the brain—by the removal from the body, at these times of great intellectual activity, of large*

Can the mind think independently of the brain? How are we to regard the activity of the mind? What proofs that the brain is the mental instrument? What proofs that the mind uses the brain for thinking?

Fig. 5.



Brain composed of parts—Its ganglia.

amounts of substance produced by activity of the brain, and by a greater demand for food at such times, especially such kind of food as is adapted to renew the exercised brain.

Illus. A.—Students have usually a greater appetite during term time than in vacation.

Illus. B.—Professional men are usually more fond of eggs, fowls, fish, oysters (especially at or after times of great intellectual labor), than of ham, corn cake, puddings, &c.

58. *The numerous duties of the mind require* that the brain should be composed of many parts, exhibiting a very complicated organization; this is the case, the different organs which compose the brain being called ganglia (ganglion, singular).

It has not yet been possible to determine with certainty the use of each part of the brain. It is not yet certain whether the brain is a single apparatus or a collection of several. It is nearly certain however, that several parts form an apparatus of thought; several others a sensory apparatus; and several others a motory apparatus; and some think the apparatus of thought is divided into two: when we should have, 1st. Intellectual; 2d. Emotional.

BRAIN	$\left\{ \begin{array}{l} \text{SENSORY,} \\ \text{EMOTIONAL,} \\ \text{INTELLECTUAL,} \\ \text{MOTORY, or VOLITIONAL.} \end{array} \right\}$	GANGLIA.
-------	---	----------

There are many arguments in favor of the last idea. I am inclined to favor it.*

59. *The constant progress and development of the mind*

* I am aware that the division of mental operations into sensational, emotional, intellectual, and volitional, is not according to the metaphysical authority of by-gone days; but physiology cannot follow psychology, but must be allowed to take precedence. Yet, I enter not upon any metaphysical debate with any one; I shall restrict myself to the domain of physiology, and immediately yield any point which does not conflict with it.

When have students an appetite? Why? Why should the brain be composed of many parts? What are its parts called? What is said of the probable divisions of the brain? What division of ganglia is the author inclined to favor?

Progress of Mind—Progressive changes of Brain—Education necessary.

requires corresponding progressive changes in the brain. These are constantly taking place.

60. *The progressive changes* in the brain have a twofold character. They take place in accordance with the age of a person and in accordance with the mental activity.

61. *Man is conspicuously distinguished from animals* by the character of the changes which adapt his brain to his mental necessities.

In animals the changes result in repetitions; at most, the changes are progressive only as it respects age; while in man mental action is constantly influencing the character of the changes which take place.

62. *Education, either good or bad*, is constantly going on in man from birth till death. This education is of a twofold character—mental and physical. While on the one hand mental action influences the changes occurring in the brain; on the other, the changes of the brain influence the mind.

Illus.—The boy should be desirous of gathering knowledge. He is accordingly full of life, and desirous of muscular exercise. He is continually asking questions. At the meridian of life man is more demure, and gives himself to business. When old age arrives, he loves to sit still all day, reflect and counsel. He forgets things of yesterday, which his juniors know as well as he, and becomes garrulous about his youthful days. If he asks a question, the rising inflexion of the boy is heard no more, but the teaching cadence instead. The shallow, forceless voice of the child, has been also changed for the weighty tones of ripe judgment.

The most important inferences are to be drawn from the facts advanced:

Progress of mind requires what? How do brainial changes take place? How man distinguished from animals? How do the result of changes in man and animal differ? When is the education of man at its end? What differences should there be between the boy and old man?

Important Inferences—Sensory Apparatus needed.

Inf. a.—The original constitution of the brain is of great consequence.

Inf. b.—The daily nutrition of it should be perfect; the kind and quantity of food eaten should be attended to.

Inf. c.—Every influence which a person allows to act upon his brain should be scrutinized with the utmost care.

Inf. d.—Parents should watch over their children from the *earliest* periods of life.

Inf. e.—The public are constantly educating children either well or badly. The grog shop on the corner has an effect on all citizens. The school-house should take its place.

CHAPTER II.

To acquire knowledge sensory apparatus necessary—Touch, Taste, Smell, Seeing, Hearing—Muscular Sense—Tableau.

Though the brain is adapted to receive the action of, and act upon the mind, on that very account it is too delicate, and on various accounts not adapted to directly act upon or receive the action of the world.

An apparatus is needed to serve as a medium through which the world can act upon the brain. It must be constituted of two parts, one to receive the action of the world, and the second to communicate between the first and the brain. The first is called an organ of sense, the second is called a nerve.

63. *Sensory Apparatus* is the name given to the three parts now seen to be necessary to allow the world to act upon the mind, viz. :

WORLD. ORGANS OF SENSE; NERVES; GANGLIA. MIND.

└──────────┘
 BODY.

Upon a review of the facts stated in this chapter, what important inferences are to be drawn? Of how many and what parts is the medium between the world and brain constituted? What is a sensory apparatus?

 Functions of the Sensory Apparatus.

Fig. 6.

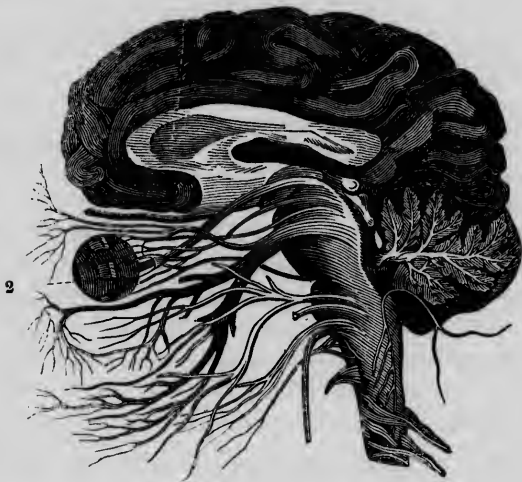


Fig. 6 presents a view of the brain and a number of nerves, and 2, one organ of sense: the eye. At the lower part is seen a large bundle of nerves called the spinal cord, from which branches lead into all parts of the body, Fig. 5. Thus are all parts connected with the brain, or placed in communication with it, and also with the mind.

64. *The functions of the sensory apparatus* are numerous. 1st, to warn us of dangers; 2d, to excite in the mind those elementary ideas by which, upon reflection, it learns the qualities and characteristics of things; 3d, to produce pleasant sensations.

Says Le Cat in his treatise on the senses, when speaking upon the ear, "Life deprived of sensations as useful as those of hearing, would be a kind of premature death. A deaf man is necessarily

Describe Fig. 6. What are the functions of the sensory apparatus? Give an illustration of each case. Give a second under each head. Repeat what Le Cat says of a deaf man.

Several kinds of Sensory Apparatus required—Sense of Touch and Taste.

a dumb man ; and who can compute his loss ? His never-sleeping guard, that warned him of a thousand dangers, is dead, and now, the tread of the midnight thief, the crash of the falling tree, the scream of the drowning child, and the mutterings of the coming storm, fall on his ear like the tear of sorrow on the brow of death. Who can compute his loss ? The sweet echoes of the valley, the voice of friendship, the hallelujahs of the Sabbath, and the loud artillery of heaven, are alike condensed into barren nothingness ; and, in the very excess of stillness, he loses all the pleasures of solitude."

65 *Several kinds of Sensory Apparatus* will be required : we desire to know whenever objects touch us, and what their temperature is ; also, when any part is injured by being cut, bruised, or for too long a time compressed. These several things we learn by means of the apparatus of touch. Its organ of sense is the skin, and through it the world acts in this wise—

WORLD—SKIN, NERVE, GANGLION, MIND.
└──────────┘
 BODY.

66. *It is desirable that we should appreciate the qualities of Food.* For this purpose the apparatus of taste has been provided. Its organ of sense is the mouth. The mind is acted on as follows :—

WORLD—MOUTH, NERVE, GANGLION, MIND.
└──────────┘
 BODY.

67. *Minute particles of matter*, disseminated in the air, are sometimes very injurious. It is not only well that we can perceive them, but also the relishable character of agree-

Why will more than one kind of sensory apparatus be required ? What do we learn by the apparatus of touch ? What parts of the body are concerned in touch ? What parts are concerned in tasting ? Of what use is the sense of smell ?

Apparatus of smell, sight, and hearing necessary.

able food. For such purposes, behold the apparatus of smell. Its organ of sense is the nose.

WORLD—NOSE, NERVES, GANGLIA, MIND.
 BODY.

68. *The direction of Objects* not in contrast with us it is essential to know. Since they are not in contrast with us they must cause something to act upon us. This is called light. Of this there must be several kinds, or minute objects, when very near each other, could not be distinguished.

Illus.—A piece of white paper upon a white ground does not appear distinctly. A piece of charcoal does not make a perceptible mark upon a black board.

69. *The Apparatus of Sight* is necessary, that we may perceive the direction of objects not in contact with us. The eye is its organ of sense.

WORLD—LIGHT, EYE, NERVE, GANGLION, MIND.
⏟
 BODY.

In one sense the light may be called a part of the world ; but the idea is better presented as above.

70. *An Apparatus which shall be acted upon by the waves of air is quite essential to well-being and happiness. The waves of air are caused by every moving object, since the air surrounds us, and all things with which we are in immediate relation. The apparatus of hearing has the ear for its organ of sense.*

WORLD—AIR, EAR, NERVES, GANGLION, MIND.
Body.

What is the organ of sense of smell? Why must light exist? Why must there be several kinds of light? For what is an apparatus of sight necessary? Of what is the hearing apparatus constituted?

 Apparatus of the muscular sense.

The air may be said with correctness to be part of the world; but as it is not the cause of its own waves, the rationale of the whole operation will be better appreciated if the steps are noticed as above.

71. *The density of objects* the mind desires to know. It can learn by causing pressure upon them. The degree of pressure made, and the resistance felt, will indicate the degree of hardness. It is also desirable to know the weight of objects. The effort necessary to ascertain them will indicate the weight. The position of the various parts of the body, and the extent of motion they have made, it is also desirable to know. All these things are determined by the apparatus of muscular sense. Its organ of sense is the muscles.

This is the name given to the parts which constitute the lean meat. Many of these are represented by Plate 2. They contract to produce pressure, to sustain weights, and to produce most of the positions and motions of the body. The contraction produces an effect upon the nerves, commencing in them, and thus the mind is at last acted upon, the effect depending on the degree of contraction.

MUSCLE, NERVE, GANGLION, MIND.
 └──────────────────┘
 BODY.

It might at first seem that the properties of the world do not act on the mind through the muscles, because the effect is not direct, and the world is not brought into the chain in the tableau. The following figure will show that an effect may be produced.

72. *These six kinds compose* a class of apparatus by means of which the mind becomes acquainted with the external world. This is called the external or objective class. The same things are to be learned in respect to each kind

How can the mind learn the density of objects? How the weight? How the position? What is the common name of the muscular part of man and animals? How many kinds of apparatus of sensation have been mentioned?

Things to be learned in Anatomy—Each kind of Sensory Apparatus.

Fig. 7.



composing it: 1st, the character of objects that act upon it; 2d, the constitution of the organs of sense; 3d, how in it the nerve commences and is acted upon, its constitution and course, and how it terminates; 4th, the constitution of the ganglia, their action upon the mind; 5th, the effect produced in it.

73 *Our necessities require* that the mind should have an idea of the state of the various parts of the body itself. An apparatus of internal sensations will be necessary. Its organs of sense are, every part of the body, viz. :

EVERY PART OF THE BODY—NERVES, GANGLIA, MIND.
⏟
 BODY.

74. *In studying this class we have to consider*, 1st, how the nerves commence their course and termination; 2d, the ganglia, and their action upon the mind; 3d, the effect upon it.

75. *Impression is the name* given to the effect produced upon any nerve, e. g., impression of taste, smell, &c.

76. *Sensation is the name* given to the effects produced

How many things are to be learned in studying each kind of sensory apparatus? Why is an apparatus for internal sensations necessary? In studying the apparatus of internal sensations what are to be considered?

 Sensorium—Brain an organ of sense—Sensations grouped.

by the ganglia upon the mind, e. g., sensation of touch, sight, &c.

77. *Sensorium* is the name given to the collective sensory ganglia. It must always be kept in mind that sensations are here produced. It makes no difference how the action of the sensorium is caused, sensation is always produced by its action.

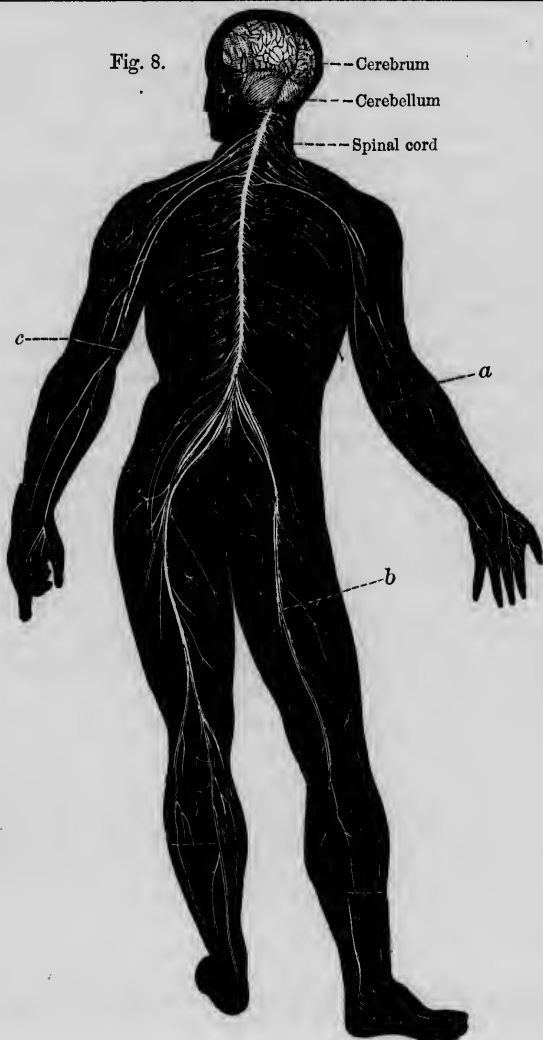
Since, then, the mind is not in the finger but at the sensorium, how shall it determine, when the finger is pricked, what part is acted upon? The mind and sensorium must be so constituted that when a sensation is caused through any particular nerve, the mind shall refer the sensation to the point where the nerve naturally commences. It is so. It follows that if a nerve be pricked in some part of its course, as at *a*, fig. 8, the mind refers the sensation to the little finger, where the nerve commences. If the corner of the elbow strike a piece of furniture, the little finger feels numb, because the sensation is referred to that point. If we compress the large nerve, called the sciatic, *b*, fig. 8, by sitting uncomfortably, the foot will soon be "asleep." Hence, when a limb is taken off, as at *c*, fig. 8, and the nerve at or above the stump is touched, the mind refers the sensation to the position where the nerve naturally commenced; and it seems to the person as if his hand yet remained. Since diseases frequently affect the nerves in their course, or the sensorium itself, reliance cannot always be placed upon sensations, or their apparent cause.

78. *It should be borne in mind, emphatically, that the brain is an organ of sense* which acts very powerfully upon the mind, perhaps through the medium of the nerves and the sensorium; perhaps directly. The sensorium, which is a part of the brain, is also to be included among parts of the body the action of which causes sensations.

79. *All sensations may be grouped* as pleasant, unpleasant, or negative. Pleasant sensations are produced when

What is the sensorium? When the finger is pricked, why does the pain seem to be in the finger? Can reliance always be placed on sensations? Is the brain an organ of sense? How does it act? How may sensations be grouped?

Fig. 8.



Advantages derived from the Sensory Apparatus, and its study.

the action of objects in the various parts of the body is healthful, and should be continued. Unpleasant sensations warn us of dangers. Negative sensations are those which are not perceptibly pleasant or unpleasant.

The action of poisons and the exhilarated mind is frequently productive of pleasant sensations. The nervous system is then perniciously affected. Education, especially physiological education, is necessary, that the character of nervous influences may be discerned, since we cannot be, like the animals, correctly governed by sensations and instincts.

80. *The sensory apparatus* is one of the most valuable topics of Physiology. If we study its character, we see how important to a healthy action as well as happiness of the mind a healthy and properly active body is.

All parts having been designed for that action which at any time of life is best adapted to present and ultimate mental improvement, produce the most pleasant sensations when they are properly exercised. The healthy lungs, receiving pure cool air, exert through the nerves that communicate with the brain, such influences upon it as make the mind enjoy life better, become more amiable and capable. The stomach which digests wholesome food in proper quantity, causes the most highly rewarding sensations. It is therefore foolish to eat food for the sake of enjoying its savor, when its effect on the stomach will be the cause of languor or irritability. Care should be taken that every function of the body be well performed, in order that we may enjoy life and render it efficient.

81. *The study of the sensory apparatus* will convince us that we should cultivate the senses to a high degree, and, so far as possible, properly arrange the world; that we should especially open and educate the senses to the world's favorable influences, and also educate the mind to enjoy the action of the world.

Are all pleasant sensations healthful? What effect on the mind does a healthy and active body have? What kind of action are all parts designed for? Why should every function of the body be well performed?

Advantages of educating the senses—Extensive practical field.

This subject opens an extensive, practical field. Not only is it important to educate the senses to acquire knowledge, but to enjoy life. The school-rooms for students, the shops of mechanics, the farms, the offices of professional men, the stores of merchants, the dwellings for families, should have pleasant situations, and be surrounded and furnished with the causes of enjoyment to the educated, exercised senses, and educated mind. Music should be cultivated, and the fine arts. This study will teach a person that his happiness consists not in hoarding money, or in the exercise of coarse tastes; not in dissipation, or coveting the things of others, but in being refined, educated, and industrious; in opening to the mind free avenues for the reception of the gratuitous blessings which the Creator is every moment pouring in upon those who are ready to receive them. This study teaches, that true manhood depends not upon any artificial, comparative position in society, but upon *personal* development and refinement which is to be accomplished by each individual for himself. If not done, he cannot fully enjoy life, or profit by it, no matter what false ideas he may have. If done, he is a man, whether he hold the hammer at the anvil, the plough in the field, or pour forth eloquence to a delighted auditory. Would that all men could perceive and thoroughly understand how much they are capable of enjoying even through the properly exercised senses, if only the mind is properly educated, and how influential this exercise is upon the mind, especially in respect to amiability.

Blest power of sunshine! genial day;
What balm, what life are in thy ray!
To feel thee is such real bliss,
That had the world no joy but this,
To sit in sunshine calm and sweet—
It were a world too exquisite
For man to leave it for the gloom,
The deep, cold shadow of the tomb.—*Moore.*

82. The following tableau presents the sensory apparatus grouped.

An apparatus of sensation includes, $\left\{ \begin{array}{l} \text{Organ of Sense,} \\ \text{Nerve,} \\ \text{Ganglion.} \end{array} \right.$

That an objective sensation may be produced, there is needed an
OBJECT, ORGAN OF SENSE, NERVE, GANGLION, MIND.

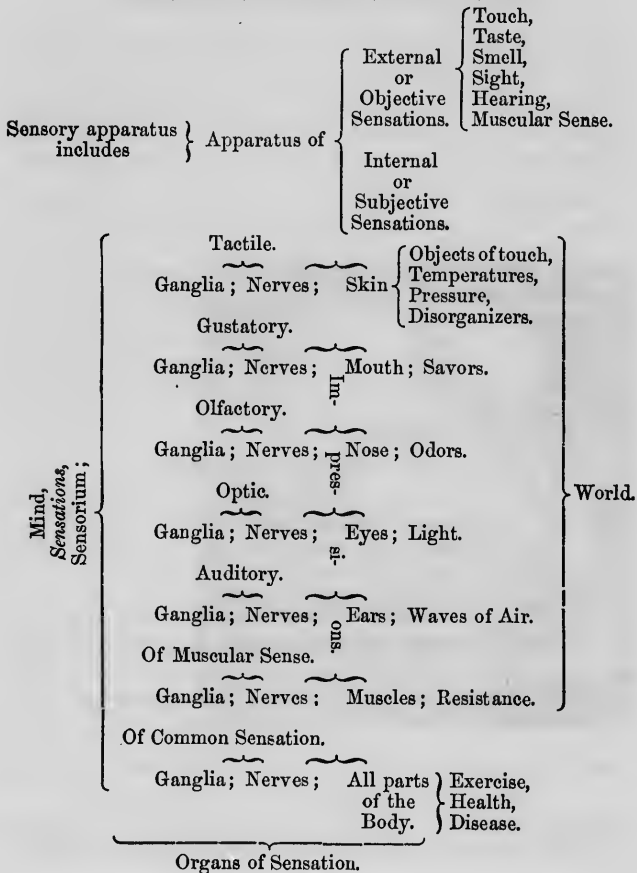
What will the study of the senses teach? Apparatus of sense includes what?

That a sensation may be produced, two things only are absolutely necessary,—

GANGLION AND THE MIND.

The farther from the mind the first cause of the sensation is, the more complicate the means necessary to produce it, e. g., "To see" the sun or a candle there are required six steps:

CANDLE; LIGHT; EYE; NERVE; GANGLION; MIND.



CHAPTER III.

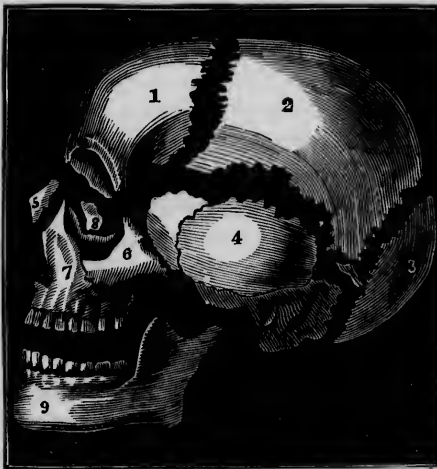
For protection, locomotion, handling, and speaking—Skeleton—Muscles and Motory Nerves needed—Tableau.

Protective and Motory Apparatus.

83. If we suppose the brain and organs of sense adapted to the use of the mind in thinking and feeling, or acquiring knowledge, the next thought is, that such delicate apparatus will require very efficient protection.

84. *The desired protection of the brain* is found in the cranium composed of many bones (Fig. 9) locked together,

Fig. 9.



The bones of the skull separated.—1, Frontal, only half seen. 2, Parietal (wall). 3, Occipital (back), only half is seen. 4, Temporal. 5, Nasal (nose). 6, Malar (cheek). 7, Superior (upper) maxillary (jaw).—8, Unguis (nail form, being about the size and thickness of the finger nail). 9, Inferior (lower) maxillary (jaw). Between 4 and 6, a part of the sphenoid or wedge-shaped bone is seen. Another bone assisting

to form the skull, but not here seen, is called the ethmoid (sieve-like) from being full of holes, and situated between the sockets of

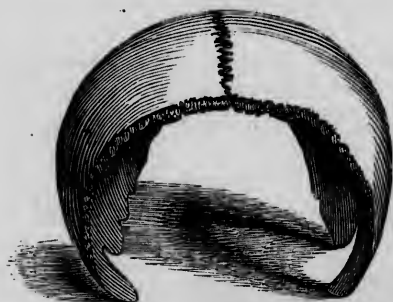
Page 68.—What alone is sufficient to cause a sensation? What does sensory apparatus include?

What does the delicate brain require? In what is the protection of the brain found?

 Protections of the brain and organs of sense.

and presenting an arch, the strongest of architectural devices (Fig. 10), in every direction where it is liable to fracture.

Fig. 10.



85. *The protections of the organs of sense* are found in bones added to the front, lower part of the cranium. In front, the sockets of the eyes are formed, and the air-passages of the nose. The lower edge

of the upper jaw bones is formed with sockets for receiving the upper teeth. Opposing these, the teeth of the lower jaw are set in it, which is hinged to the skull in such a way that it can move up and down, and from side to side, thus causing the food to be comminuted and fit to produce the greatest effect upon the organ of taste. To the sides of the head very solid bones are united, called petrous (rocky) bones, or petrous portions of the temporal bone. These protect the apparatus of hearing.

86. *In addition to the protection afforded by the skull*, it is covered with the muscles, tendons, skin and hair; but if we conceive the head to be perfectly formed for protecting the organs of sense and brain, which are also perfectly adapted to the requirements of the mind, yet that it may the eyes, and forms the roof of the nose. 2, 4, 5, 6, 7, 8 are double. The small bone, seen in a line between 3 and 4, and others like it, are called ossa triquetra.

In what are the protections of the organs of sense found? How are they protected? How air passages formed? How the buccal cavity? How are the organs of hearing protected? What beside the skull affords protection to the brain?

Structure of a locomotive framework—The foot.

use its apparatus to any very extensive profit, it must be locomoted wheresoever the mind wishes to observe. For this purpose there must, first, be a framework.

87. *The simplest and best locomotive framework* would consist of two levers; one end of them must be adapted to rest upon any kind of ground, and the other to turning in every direction.

It might be suggested that a wheel would best serve the purposes of locomotion. It will be seen that a wheel has a certain resemblance to the legs of an animal, but is a very clumsy representative of those superlative pieces of mechanism. The spokes are inflexible levers which are fastened into a continuous rim, which forms a foot for them all, if we may so disgrace a foot as to make this awkward comparison. If a piece of the rim was given to each spoke, the idea would be more conspicuous. Instead of these spokes swinging backward and forward like a leg, whereby only four would be required, they revolve, and some 50 are required. They cannot move from side to side, but must go right on. It is almost wonderful that some mechanic has not cast aside this human invention, and, imitating nature, produced something more perfect.

88. *The lower part of the lever*, which is adapted to the ground, must be composed of many small pieces jointed in the strongest manner, yet so as to slightly move upon each other. This is the case with the foot.

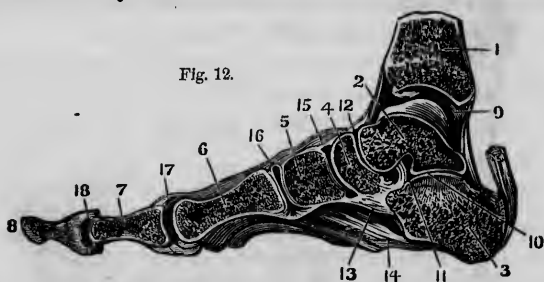
Fig. 11.



Fig. 11.—View of upper surface of foot. 1 to 8, Bones of ankle. 9, Metatarsal or pre-ankle bones. 10 to 14, Bones of the toes.

Why is locomotion of the brain necessary? How make a locomotive framework? What objections to wheels to move the body? How must the lower part of a locomotive lever be made? Describe Fig. 11.

89. *The foot is so jointed to the leg as sometimes to form part of the lever, and again is a base to support the leg and the body above it.*



Section of leg and foot bones. 1, Lower part of tibia. 2 to 5, Ankle bones. 6, Metatarsal. 7, 8, Toe bones. 9 to 18, Joints and synovial ligaments. The great toe has only two bones.

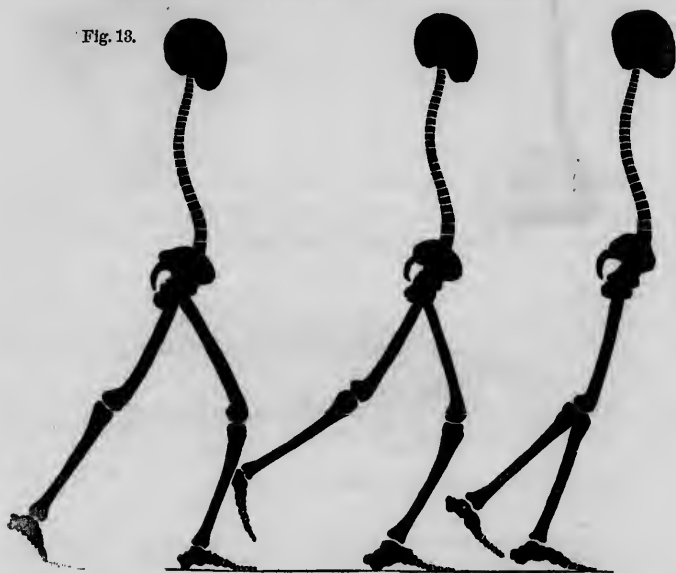


Fig. 13 represents, 1st, the feet and locomotive levers in several posi-

Fig. 14.



90. *The upper end of the lever must be finished like a ball that it may be received in a socket and turn in every direction.*

Fig. 15.



Fig. 14 represents the thigh-bone. 2, The ball which fits the socket, S, of fig. 15, which represents a side view of the hip bone.

91. *About the middle, the lever must have a joint of a hinge character, that the foot may be easily raised over obstacles, and that a person may go up and down stairs, a ladder, hill, &c.*

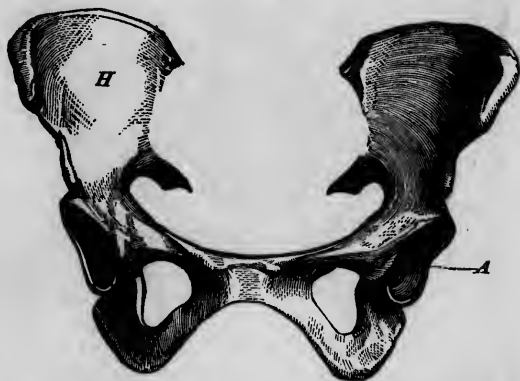
tions when walking. 2d, The bodies of the vertebræ of the back with spaces, which in life are filled with the beautiful springs called intervertebral substances. 3d, The natural curves of the spinal column. 4th, That the natural position is erect and dependent chiefly on the condition of the intervertebral substances.

What are the advantages derived from the ankle joint? Describe Fig. 12. 13. 14. 15. Why should there be any joint at the middle of the locomotive lever? Which way should the knee joint allow the leg to move?

Use of hip bones—Brain protected from jars.

92. *A heading must be adapted to receive the upper extremities of the levers.* The hip bones, with a socket excavated from the outside of each, and strongly fastened together, are quite perfect.

Fig. 16.



Front view of pelvis. 5, Lower lumbar vertebra. 4, Cartilage between the vertebra and sacrum, S A. H, Hip bone. A, Acetabulum; the socket of the hip.

It might be asked why might not sockets have been excavated from the sides of the skull, and the head been placed directly upon the locomoting levers? 1st. It would have been too violently jarred. 2d. There would not have been proper surface or positions upon it for the attachment of locomoting muscles. 3d. The partial cavity presented by the hips was needed for the protection and support of the abdominal organs.

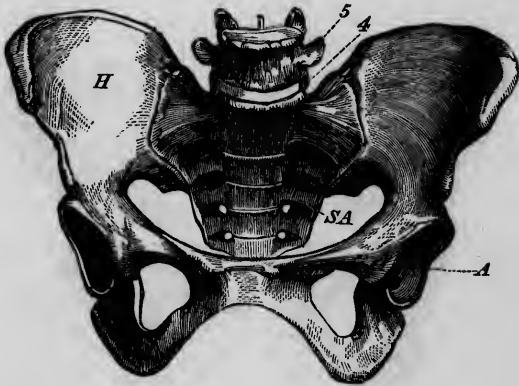
93. *To protect the brain and organs of sense from jars,* the head must be supported upon an elastic apparatus placed upon the hip bones; for this purpose a strong wedge-shaped

What is the use of the hip bones in respect to locomotion? Why might not sockets be excavated from the skull, or added to it, for receiving the heads of the thigh bones? How must the brain be protected from jars? Describe Fig. 16.

 Vertèbral column—Intervertebral substance—Sacrum.

bone, called sacrum, is bound between and rests upon them at the back part, as in fig. 17.

Fig. 17.



94. Upon the sacrum is raised up a column composed alternately of bone and an elastic substance something like the ear, but which can be compressed without causing pain. The bones are called vertebræ, and the elastic substance, intervertebral substance (see fig. 13). The column thus formed has a double curvature, by means of which a part of the force which would otherwise reach the head, is scattered.

95. The column is more elastic and stronger, as well as adapted to the organs within the chest and abdomen for these curvatures. It is also to be noticed that the irregular shapes of the bones and their flexions at the joints disperse

Where is the sacrum situated? Describe Fig. 17. Of what is the column resting upon the sacrum composed? What effect has the curvature of the column upon its strength?

Force scattered—Osseous cancelli.

the force which acts through the foot when it strikes the ground (see fig. 18).

Fig. 18.

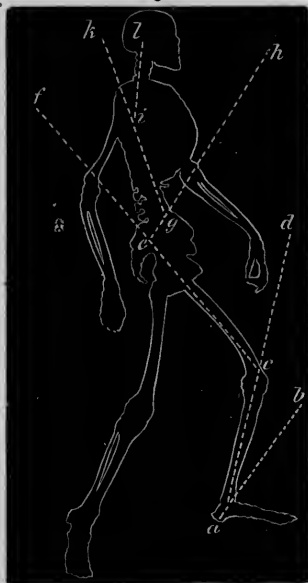


Fig. 18.—This outline represents the skeleton walking. The dotted lines represent, in part, the dispersion of the force acting on the heel at *a*, viz.: a part of the force acting through the ankle, is lost in the direction of the dotted line *a b*, only a part of the force acting in the direction of the line *a c*; of this, only a small part will act in the direction *c f*; and of this, only a part in the direction *e h*; of this, only a part in the direction of *g k*; and of this, only a part in the line *i l*. In fact, these lines represent but a small part of the directions in which the force is scattered; for, by the curve of the thigh bone, its neck and the connection of the hip bones with the back bone, as well as the continued curvature of this, the head is saved from the sudden jar produced when the body is as erect as it can be; for instance, when a misstep is made, or a person falling strikes upon his feet.

96. Again, when divided, the bones are found to be full of irregular spaces or holes, called cancelli. (Fig. 19). Some bones exhibit large canals in their centre. These canals and cancelli are filled with marrow. This, with the want of solidity in the bones, is very effective in deadening the jars which would otherwise act through the bones.

Exp. *a*.—Fill a glass vial or tumbler with water, and then with

What does Fig. 18 represent? In how many different directions is force scattered, as shown by the figure? What is the structure of a bone? Have you examined a bone to ascertain if the author is correct? What experiment is mentioned?

Spinal column—Processes of its vertebræ.

oil; if struck when empty the glass rings sharply, sounds dull when water is in it, and still more so when it contains oil.

Exp. *b*.—Hang a bone between a row of ivory balls; raise one and allow it to drop against the rest, the bone will deaden much of its force; fill the bone with marrow and the effect will be greater.

97. But if the column were formed only of bones and elastic substances as already described, the head would be thrown to one side and the other with violence and danger whenever a person walked ever so carefully. The column must be stayed, and for this purpose its various bones must be furnished with projecting points called processes.

Fig. 19.

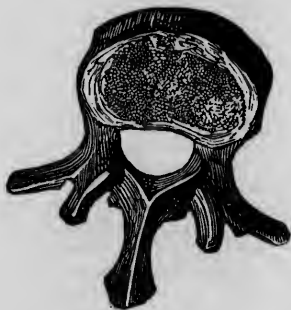


Fig. 20.

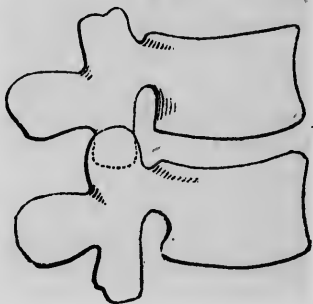


Fig. 19.—A vertebra representing the body, the hole, the lateral (side) processes, and the spinous (spine-like) or posterior (back) process.

Fig. 20.—Two vertebræ erect, showing the bodies and superior (upper), inferior (lower), articulating (jointing), and spinous processes.

98. *Some of the processes are very long, and connected by movable joints with the bones of the column. These are*

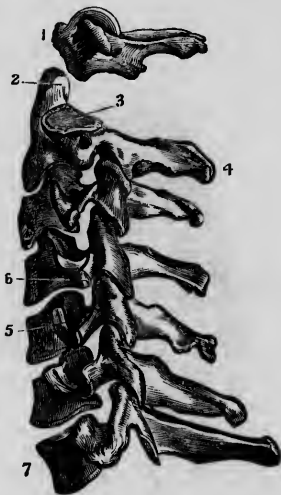
Have you tried the experiment *a*? What is experiment *b*? Have you tried it? If the column was constructed as represented in fig. 13, what would be one bad effect of motion? Why must the column be stayed? Describe Fig. 19. Describe Fig. 20.

 Ribs—Nodding and revolving motion of head.

called ribs. They are curved, and connected by means of cartilage with a bone in front called the sternum or breast-bone. Thus the framework of the chest is formed. When muscles are connected with the hip bones and processes of the spinal column and the ribs, the spinal column can be stayed upright or flexed in any direction.

99. But it is sometimes desirable to nod or turn the head quickly. For this purpose, the head rests upon the bone 1 (Fig. 21) in such a way that the nodding motion is obtained. The bone 1, called the atlas, rests upon the bone 2, 3, 4, (Fig. 21.) The point or tooth-like process 2, passes up through an appropriate hole in the atlas, and is fastened to the skull. The bone 1, with the skull it supports, partially revolves on bone 2, 3, 4, called the dentatus. Thus protection with great latitude of motion is obtained for the head, by the beautiful structure of the spinal column.

Fig. 21.



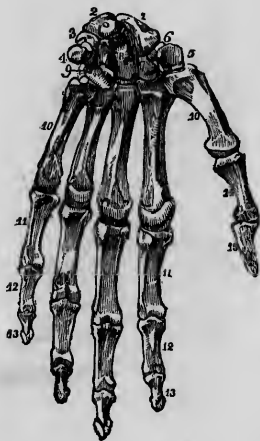
100. To gain knowledge the mind requires a means of taking up objects and moving them from one place to another. A handling apparatus is needed to pick up objects, and grasp them securely; nothing could be better than four levers of

What are ribs? How is the chest formed? What is the form of ribs? How is the nodding motion of the head obtained? How the turning? Why is a handling apparatus needed?

Handling apparatus—Hand, arm, and elbow joint.

unequal length, with three joints, and finished at the free extremities with a sharp edge, and opposed by a shorter stout lever with two joints. They must be connected with a common centre, composed of several small parts, strongly joined, yet slightly movable. Such is the framework of the hand, together with the nails. A more admirable piece of apparatus cannot be found. If it had not been daily seen, but was to be first exhibited as a curiosity, it would be considered as the wonder of the age.

Fig. 22.



Palmar (Palm) surface of the left hand. 1, Scaphoid. 2, Semi-lunar. 3, Cuneiform. 4, Pisiform. 5, Trapezium. 6, Trapezoid. 7, Trapezoid. 8, Magnum. 9, Unciform. 10, Metacarpal bones. 11, 14, First; 12, 15, Second; 13, Third; rows of phalanges.

101. To move the hand and the object seized, a lever will be required. To it the hand must be attached by a movable joint, while its upper extremity must be finished like a ball, that it may every way turn in a socket; near the centre, the lever must have a hinge-joint, and below this, the lever should be composed of two pieces. See Fig. 23.

102. One of these, properly speaking, belongs to the hand, and by partially revolving round the other, gives that useful

What is the use of the nails? Of what is the hand composed? Describe Fig. 22. Why is a lever required? Why is an elbow joint needed? Describe the two bones of the lower arm.

 Socket at the shoulder—Scapula—Clavicle.

motion seen when a key or a gimlet is turned. Of the two, the ulna only assists to form the elbow joint, and the radius that of the wrist.

Front view of bones of lower arm. 1, Shaft of ulna. 2, Greater; 3, Lesser sigmoid (S-shaped) notch. (The surface 2, is applied to the humerus.) 4, Olecranon process (point of elbow). 5, Coronoid process. 10, Ulnar Shaft. 11, Head. 12, Neck. 13, Tuberosity. 15, Inferior head. 16, 9, Styloid processes of Radius and Ulna.

Fig. 23.



103. But even with the ball and socket joint, the arm would not have sufficient latitude of motion. The socket itself must be movable. It forms part of the shoulder blade, the other part, which is thin, is placed upon the upper and back part of the chest, and serves for the attachment of the numerous strong muscles, which, through it, move the socket. See Fig. 24.

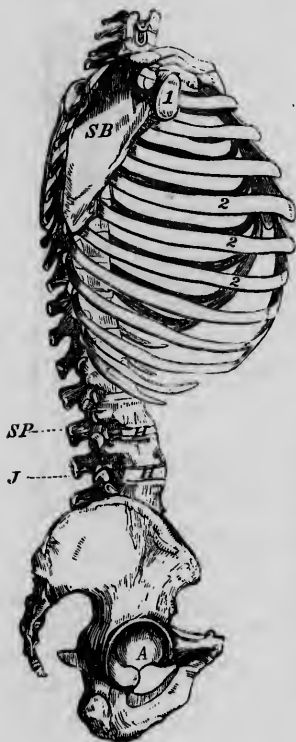
104. The socket must not be allowed to lie down in contact with the chest, but must be kept out by means of a brace. This is found in the collar bone, or clavicle, which is connected by one end and a movable joint, with the upper part of the breast bone, and by the other with the socket portion of the scapula. The clavicle represents a radius of a sphere, in the circumference of which the socket moves. Thus are we able to sweep the hands through a great distance, and by folding one part of the lever upon the other, to carry them to any point between the centre of their

How is the motion when a key is turned produced? Describe Fig. 23. Why must the shoulder of the socket be movable? Why must the socket be sustained away from the chest? What is the clavicle?

Lateral view of spinal column—Hips, Chest, &c.—Speaking apparatus.

sphere and its outer bounds, which by flexure of the back, is still farther enlarged. When I consider the beautiful mechan-

Fig. 24.



ism of the human framework, and its curious adaptations, my mind is always overcome with feelings of admiration that cannot be expressed.

Lateral view of spinal column. Scapula. Clavicle. Chest. Hip bone. Lower portion of sacrum, and of coccyx. SB, Scapula. 1, Glenoid cavity. 2, 2, 2, Ribs. SP, Spinous process. H, H, Intervertebral substance. A, Acetabulum.

105. But the subject is not yet exhausted. To acquire and communicate knowledge, the mind still further requires the framework of a speaking apparatus. This apparatus must consist of a bellows, and intoning and articulating organs. The framework of the chest being movable, can increase and diminish its cavity: if it be lined, and closed at the bottom, a bellows will at once be formed. For a nose or tube an elastic substance is required, this we have in the windpipe,

What advantages result from the bending of the arm at the elbow joint? Describe Fig. 24. Why is a speaking apparatus needed? What is the use of the chest in speaking? What is the use of the windpipe?

Larynx—Hyoid bone—Tableau of skeleton.

or trachea, the upper part of which tube is composed of several pieces movable upon each other, and called the larynx. It is kept in place partly by means of a bone called the hyoid or U-shaped bone. In the larynx the tones can be produced, while articulation requires nothing more perfectly adapted than the various parts of the mouth.

106. *The skeleton is a unit*, or whole, each part of which is adapted to the purposes of every other part, and of the whole. Yet the framework is divisible into several classes of parts, which may without inpropriety be spoken of as if designed for particular purposes, as in the following synopsis.

The Skeleton is composed of	HEAD,	Rigid Protective Apparatus.
	FEET, LEGS, HIPS,	} Framework of Locomotive Apparatus.
	SPINAL COLUMN,	Framework of Elastic Protective Apparatus.
	RIBS, BREAST BONE, WINDPIPE, LARYNX, HYOID BONE,	} Framework of Speaking Apparatus.
	SHOULDER BONES, ARMS, HANDS,	} Framework of Handling Apparatus.

107. *How shall motion of this beautiful, but by itself motionless framework, be caused?* Two things seem necessary:—1st. That something be connected with it, and have the power of moving it. 2d. That some means exist of communicating between the mind and the immediate moving cause. Such an arrangement is found:

What is the use of the larynx? Into how many classes of parts is the skeleton divisible? Give the tableau of the parts and uses of the skeleton. Write it out on the black board. What two things are necessary to produce motion of the framework?

Muscles—Their peculiar property is contractility.

108. *The lean meat of animals and man* is composed of fleshy threads gathered into numerous bundles of various sizes and forms, called muscles.

Illus.—The drumstick of a fowl shows this arrangement. Plate 2 exhibits many of the human muscles.

109. The muscle itself could not be directly and strongly connected with the frame. The connection is made by means of a strong, pearl-colored substance called tendon.

Illus.—The cords on the back and front of the hand are examples.

Fig. 25.



110. *The peculiar and important property* of a muscle is its contractility. That is, under the action of proper influences, it will contract, and in a short time relax. Thus will it move one or all of the parts with which it is connected.

Illus.—Place the hand upon the front part of the arm above the elbow and raise the part below. The muscle beneath the hand will be felt to be in action. It is contracting, and causing the lower arm to rise.

111. Between four and five hundred muscles are found in the body, which is chiefly composed of them and their ad-

Of what is lean meat composed? What are muscles? What are the parts of the drumstick of a fowl called? How is the muscle connected with the framework? What is the peculiar property of muscular substance? What is contractility?

 Muscles grouped—Uses of muscles—Nerves.

junctions. But the motions produced in the human body are much more numerous than its muscles; for not only can each one produce the motion peculiar to it, but the joint action of two or more can produce motions which neither could alone.

112. *The muscles may be grouped* very much as the parts of the frame to which they are attached. One group is for locomotion; another for bending the back and head, or "staying" them; another for speaking and expression; another for handling purposes.

113. *The uses of the muscles are threefold.* 1st. They serve the mind in gathering knowledge. 2d. They are used to obtain support for the body. 3d. By proper exercise they produce pleasant sensations.

If the muscles serve the mind in gathering knowledge, they ought to be most active when the gathering of knowledge is most imperative, viz., in youth. Hence, the boy will run from dawn till dark without tiring. The old man desires to be quiet, and reflect upon the stores which his observation has gathered. The exercise of the muscles in youth is useful, not merely to develop themselves and other parts of the body, but also and chiefly to store the mind. If the muscles have been designed for exercise that the mind may gather knowledge, their best good demands that they should be exercised, not by the prosy walk, but in rambling among the works of nature, and observing them. Such time is not misspent or wasted, but well invested. The student who reads the book of Nature is equally studying as when he pores over the printed page. Gather knowledge in the natural way, and the best exercise of the muscles is necessarily secured.

114. *White pulpy cords called nerves* connect between the brain and muscles. Through these nerves an influence can be exerted upon the muscle which will cause it to contract and produce motion. It is called nervous influence,

How numerous are the motions produced by muscles? How many muscles be grouped? What are the uses of the muscles? How ought they to be exercised? Are similar exercises required at different times of life? What are nerves?

Nerves grouped—How protected—Spinal cord.

because exerted through nerves,—and motor-nervous, because motion results from its action; and the nerves are called motor-nerves from the same reason.

What this influence is, how produced, transmitted, or how it acts on the muscle, or how the mind causes it to act from the brain when desirable, is not known. Two kinds of nerves are now seen to exist; one through which influences are exerted upon the brain, and another kind through which influences are exerted from the brain.

115. *These nerves might be grouped as the muscles and different parts of the framework are; but it is not usual. They are usually counted and named in pairs, as they appear outside the brain and spinal cord. (See Fig. 5.)*

Those parts of the brain with which the motor nerves are connected are called motor ganglia, but their character and individuality have not been well made out. It is therefore rather from analogy than positive fact that we speak of motor ganglia of the brain. Some suppose, indeed, that the nerves which extend from the spinal cord do not reach up to the brain. This question will come up by and by.

116. *The nerves which communicate between the brain and distant parts of the body must be protected from injury.*

No better place could be found than the canal formed in the spinal column when the spinous processes were built out from the bodies of the vertebræ, in order that they might be more easily stayed in an upright position. (See Pl. 1.) Through each vertebra a hole was left, and of course a canal formed through the entire length of the column.

117. *The nerves, for the most part, are gathered at the lower part of the brain into a large cord, which is situated in and extends through the canal of the spinal column.*

What is nervous influence? How many kinds of nerves exist? How may the nerves be grouped? What protects the spinal cord? Of what is the cord composed?

Beautiful Hydrostatic Apparatus of the Spinal Cord and Brain.

Through holes in its sides, such portions of the nerves appear as extend to the neighboring parts.

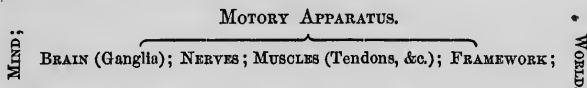
118. *The cord does not entirely fill the canal*, and is not, therefore, injured when the back is curved to the greatest degree. Within the canal, and beneath the brain, a hydrostatic apparatus of the most useful character is found. The space between the cord and wall of the canal is coarsely divided into areolæ or small spaces which communicate with each other, and are filled with fluid; this affords the same result as if the cord were surrounded by a column of fluid. The same arrangement exists in the head, under the brain, which does not rest directly upon the skull. The areolæ beneath the brain and around the cord communicate. Thus is formed one of the most curious and protective parts of the whole body. The brain reposes above, upon a hydrostatic or water-bed, with a column of fluid beneath, which, in this place, is the most perfect and delicate spring imaginable. If a person stoop, the curve of the spinal column will a little diminish its canal, and cause a portion of fluid to be pressed into the head, whereby the brain is firmly held from being jostled. No motion of the nervous substance can be quicker than that of the fluid; hence it is always between the brain and danger.

If such wonderful contrivances have been made to protect the brain from harm, how important it must be, and how much more important its duties. Gifted with a machine so beautiful, delicate, and well adapted for pleasure and profit, ought not every person to become familiarly acquainted with its exquisite workmanship? And when a person is acquainted with it, ought he not to feel that a momentous responsibility rests upon him if he permits it to become deranged?

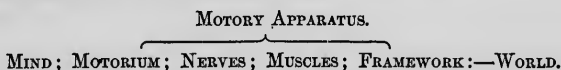
How do nerves extend from the cord to the various parts of the body? Does the cord fill the spinal canal? What exists about the cord? What between the lower part of the brain and skull? What effect upon the brain is produced by stooping?

 Synoptic tableaux of Motory Apparatus.

119. The following tableau exhibits synoptically what is necessary for producing voluntary motion.



The motory ganglia collectively are called the motorium; the following view is therefore more brief:



The mind is thus seen to be the first cause of all voluntary motion. This is one of the most practical lessons which Physiology teaches, as will be seen in the following Chapter.

120. The facility with which the mind can act, exhibit its action, and produce an effect upon the world, will depend upon its education, and the exercise of the motory apparatus.

Whether the exercise required by the motor apparatus is dependent upon the constitution of the muscles or nervous part of the apparatus, all do not agree. I suppose it is equally dependent upon both. One thing of great practical importance is certain, viz.: in order to combine the action of any number of muscles, or parts of them, frequent exercise is required; e. g., a person who is usually ill-natured will smile most melancholy when he attempts to play the agreeable, or win the attention of customers.

On the other hand a person may be very amiable, and yet ungraceful, unless the muscles are trained by frequent exercise to combined action. The muscles of the eye being active involuntarily, are in part the cause of its being considered the window of the soul. The facial muscles are very easily acted upon involuntarily, and show the mind accordingly. The muscles of speech are more subject to the will, but when in action are apt to manifest the disposition. As the movements of the eye of an actively amiable person are sprightly and attractive, so will those of any part of the body be, if by exercise its muscles be subjected to a similarly easy influence of the disposition.

What parts of the body are necessary for producing motion? What is the name of the motory ganglia collectively? What is the first cause of all voluntary motions? What facilitates mental action? To combine the action of muscles what is necessary?

Apparatus of Relation.

CHAPTER IV.

Apparatus of Relation—Tissues—Bony, Cartilaginous, Secretory, Muscular, and Nervous—Tableaux.

Apparatus of Relation.

121. Three classes of apparatus have been exhibited. They have a general purpose, viz., to establish relations between the mind and the world. They may be, therefore, and are, grouped into one grand class called the Apparatus of Relation, as in the following tableaux :

a.—APPARATUS OF RELATION, - - - { Apparatus of Thought,
Sensory Apparatus,
Motory Apparatus.

MOTORY APPARATUS.

b.—MIND;	{	Motorium;	{	- Nerves; Muscles; Framework;	}	WORLD;
		Ganglia of thought;		Brain.		
		Sensorium;		- Nerves; Organs of Sense; . . .		

SENSORY APPARATUS.

MOTORY APPARATUS

c.—MIND;	{	Volition;	{	Motorium;	{	Nerves; Muscles; Framework;	}	WORLD;
		Intellection;		Ganglia of		Brain.		
		Emotion;		thought;				
		Sensation;		Sensorium;		Nerves; Organs of Sense; -		

SENSORY APPARATUS.

How many classes of apparatus have been exhibited? What general purpose are they for? How may they be grouped? What does apparatus of relation embrace as exhibited by tableau a?

Causes which will act favorably upon the mind.

122. *Tableau b* conspicuously exhibits the complete circle of which the mind and world are the two poles, and all parts of which are in constant action, and constantly influencing each other.

123. *Tableau c* exhibits, in addition to *b*, some of the mental actions which sometimes or always are necessary in completing the circuit.

Inf. a.—In selecting an avocation, a place of business, or a home for a short time, or for life, regard should always be paid to the surrounding influences. They should always be such as to produce pleasant sensations, and improve the mind. "Constant dropping wears a stone."

Inf. b.—The place where a person is, from choice or necessity, should always be made as pleasant as possible—kept neatly—the furniture orderly arranged and of proper colors; flowers should be cultivated, both for their colors and odors; seats should be comfortable—temperatures healthful—clothing protective or thin, as is required, always loose and agreeable; especially let music exert its charms and powerful influences. A song sung, or tune played to one's own ears, is frequently the most controlling of causes to calm the ruffled disposition.

Inf. c.—A person must have a cultivated taste and disposition in order to act upon and arrange the world most favorably.

Inf. d.—As the disposition and intellect is, so must the effect upon the world be.

1. If a young lady wishes to appear gracefully and attractive, she must daily and hourly, at home as well as abroad, at school as well as the party, *be*—not merely pretend to be—sincerely desirous of making all those around her happy. She must assiduously and at all times cultivate an amiable disposition. If she wish to appear well, she must cultivate her mind so that she can arrange the colors of her dress and furniture according to good taste. See ¶ 100. The mind exhibits itself by the personal action and appearance, by the clothing, by fur-

What avocation should a person select? Mention some most to be approved? Why? How should all places be kept? What is the effect of music? How shall a person be able to arrange the world favorably?

 How to be eloquent and its importance.

niture, by the house,* by the yard, by its situation, and by whatever is the result of the mind's action. A person cannot be admired without she is admirable, nor loved, save by the mother, except she is lovely. Gracefulness depends upon active amiability. If a person wish to be amiable that she may be attractive, she thwarts herself: selfishness must be nullified.

2. If a person wish to be eloquent,† it is essential that he feel in accordance with the sentiment he wishes to express. Some ancient is said to have remarked that eloquence consisted in "action—action—action." But what is the spring of action? Feeling—feeling—feeling. Demosthenes swayed not the Athenians merely because he gesticulated, but because he first felt, to his very heart's core, the truth of what he said, and then, by correct language, gesture, and expression, poured out his ideas with all the fervor that they had inspired in his own soul. When a child is taught to read, he should be first taught to feel every shade of emotion which he ought to express. Action is to be cultivated; the apparatus used in speaking, expression, and gesture, are to be exercised; but they must, for the greatest profit, be exercised under the influence of feeling.‡ Good actors do not merely act, but, for the time, also feel themselves to be the individuals personated. Nothing is more important than for a speaker to lay self entirely aside. If he

* Often ignorant Dives is seen to exhibit himself by a very expensively built house, badly proportioned and located, and furnished in such a way as good taste would never enjoy or use. Nothing can buy refinement and mental acquirements but self-application. Without them, riches are only a disgrace; with them, the world can be fully enjoyed without money and without price.

† Who does not require the power of speaking eloquently? The blacksmith requires it, as well as the lawyer. Mechanics, farmers, and laboring men too often forget that they are (or ought to be) men, as well as workers. Many of our educated men (educated in some and noble respects) also forget the importance of being able impressively to address their fellow-men and cause the active acceptance of useful ideas. Merchants, and all who deal with men, need to understand and to be able to apply the principles of eloquence.

‡ One great reason why we have so many good scholars and composers, and but few good speakers, is, that reading is made too much mechanical; which is also true of speaking. Conversation is usually natural and good because feeling is allowed to rule and inflect the voice.

Mr. Russell has done and is doing much to impress upon the minds of teachers and scholars the importance of associating feeling and expression together; and I take great pleasure in referring to his works any one who is not already acquainted with his "Pulpit Eloquence" and other writings.

How can a young lady render herself attractive? Can she be made attractive by others? Upon what does gracefulness depend? How may a person be eloquent? Why was the great orator eloquent? What is said of actors?

 How business can be successfully transacted.

wish to make himself conspicuous, or have any personal end to gain, or if he feel superior to others, or vain of his accomplishments, or affected, he will appear to disadvantage; for, as the mind is, so will its exhibition be. If he wish to appear well, let him have something to say for the sole purpose of benefiting his hearers, and let his muscles be so exercised that he can express his thoughts most clearly and forcibly. How shall he cultivate his feelings? By mental effort in part, and in part by so arranging the world around, and the body itself, that the feelings will naturally be excited. How frequently does the sweet music of Beethoven excite the tender emotions and moisten the eye with tears. The gestures of emotions will tend to excite them; e. g., the action of striking tends to excite anger.

3. If the merchant wish to transact business successfully, he must cultivate an amiable disposition, and be sincerely desirous of pleasing his customers. He must understand how to arrange the world around him so that it shall act favorably upon himself and others. His body must also be in good condition. An unwholesome breakfast, or badly cooked, has often been the cause of disaffecting customers. Wet feet, thin garments, unhealthful temperatures, impure air, all have their influence upon the business of the merchant, the lawyer, doctor, clergyman, and every other person. By suggestions in regard to these things, and by having all right at home, the mother, wife, or daughter can earn as much as the son, husband, or father. A bouquet placed by the side of the mechanic's dinner-plate will send him whistling back to his afternoon labors, and his greater patience will often secure a good job.

4. The farmer, or whoever has the care of animals, requires a good disposition. Such a one can keep his stock in better condition, and on less food, than the surly man.* Thus, in every business and circumstance in life, whether we wish to act on the body, on our fellow-men, or on the inanimate world, a cultivated mind, intellectually and emotionally, is of essential importance.

It must also be kept in mind in this connection, that the action of the mind itself is productive of very powerful sensations. If, therefore, any outward cause produce a pleasant state of mind, it tends to continue the state. It is also to be kept in mind, that any thing which acts upon the mind tends to increase or diminish

* I have tried in vain to find a case where a surly man has fattened a hog of 400 lbs. weight. It seems to be a demonstrable fact, that a cross person *cannot* make a hog weigh as much as 500 lbs.

How can a person educate his feelings? What is necessary to the success of a merchant? What is the effect of wet feet upon the mind? How can the lady at home earn money? What effect has amiability upon the business of a farmer?

Important effect of the elevated emotions—Another view of Apparatus of Relation.

the effect of every thing else. Agreeable odors, colors, and sounds increase the relish of food. If we are compelled to act upon a person's mind unpleasantly, we must neutralize the effect by some other action; e. g., a favor must not be asked of a cold or hungry person. The effect of the higher emotions should be especially noticed. If a person have an appetite and the most wholesome food set before him, he will enjoy it only as the animal can, except he recognize the good-will which has prepared it, and is also thankful to that divine goodness which has made the satisfaction of all his proper wants a pleasure; not only having given him the ability to produce them, but also so arranged the world and man, that the act which produces his proper wants will also produce the means to satisfy them. When he recognizes this, and is thankful for it, there is a combined result of intellectual and emotional activity with the sensational, that exalts him far above the animal, to the true sphere which man ought always to occupy.

124. *Another view of the Apparatus of Relation* shows that it is composed of four classes of parts, as follows:—

APPARATUS OF RELATION is composed of

{	Framework,
	Muscles (Tendons, &c.),
	Nervous Substance,
	Organs of Sense.

125. *To form the framework*, a hard, resisting, almost inflexible, and yet light substance would be chiefly required. The bones answer these requirements perfectly. Where the bones form joints, a somewhat elastic substance, capable of being made very smooth, would be necessary.

Fig. 26.



B B represents two bones. A, the cartilages covering their contacted ends.

What the effect of odors &c., upon relish of food? What the effect of the higher emotions? How is man exalted to his true sphere? What is another view of apparatus of relation? What is required to form a framework of the body?

Cartilage of the joints, ribs, ear, nose, &c—Ligaments.

126. *The bones are incrusted* at the joints with a substance which also deepens the socket and strengthens the joint. See fig. 26. The substance is called cartilage or gristle, and in a young animal can be easily peeled off. Between the bones of the back a more elastic substance is required; and though the substance there found is called cartilage, it is not so. It is composed entirely of fibres. To connect the bony part of the ribs with the breast bone an elastic substance is necessary, and cartilage is there found. To form the ear, the tip of the nose, and windpipe, the same substance is desirable. Of it there are two kinds, the cellular and fibrous—and of this last, two varieties, the white and the yellow fibrous; and as the three are more or less combined in any part, so is its elasticity greater or less.

127. *To secure the bones at the joints* a very strong substance would be required, the arrangement of which must vary according to the joint considered. The substance is called ligament. It is of precisely the same nature as the tendons,

Fig. 27.

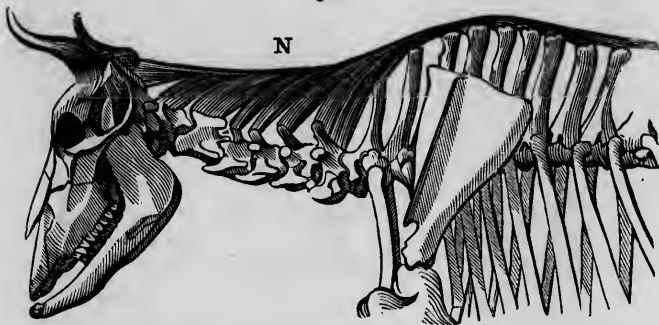


Fig. 27.—N represents the large yellow elastic ligament (nuchæ), which extends between the long spinous processes of the back and neck and the head; when the head is lowered, it must be extended.

With what are the bones incrustated at the joints? How many kinds of cartilage?

Ligaments.

being composed of fibres of a pearly white color, and exceedingly strong. The ligament is one variety of what is called the fibrous tissue. Most of the ligaments must resist any tension; but those which support the head of the cow or horse must be very elastic. Fig. 27. There are two kinds of fibrous tissue, distinguished either by their color or properties. The white is inelastic; the yellow is elastic. Some ligaments are composed entirely of one, some of the other, and some of both, being more or less elastic accordingly. Some of the ligaments are in the form of bands or straps, while some entirely surround a joint, being then called capsular ligaments. Figs. 28, 29. In case of the cap-

Fig. 28.



Fig. 29.



Fig. 28 represents the ligament bands of the hand. They are remarkably numerous.

Fig. 29.—C. L. represents part of the capsular lig. which surrounds the hip joint. It is cut open to show R. L. a round ligament in the centre of the joint, passing from the head to the socket.

How many kinds of fibres are there—Describe Figs. 28 & 29.

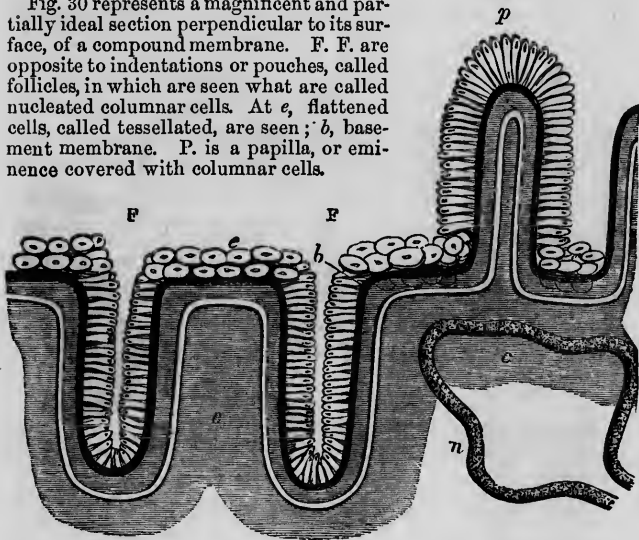
Atmospheric pressure useful in securing the bones at the joints.

sular ligament there are evidently two advantages—the bones cannot be separated without tearing it, and till it is torn they cannot separate without leaving a vacuum between them. Therefore atmospheric pressure, or what is called “suction,” is very important in retaining the bone in place.

128. The intervertebral substance is, properly speaking, a ligament. It is composed of fibres very densely interwoven, so as to form a thick elastic mass or cushion, which at the same time separates the vertebræ and retains them in their place. The upright form of the back is chiefly dependent on these ligaments.

Fig. 30 represents a magnificent and partially ideal section perpendicular to its surface, of a compound membrane. F. F. are opposite to indentations or pouches, called follicles, in which are seen what are called nucleated columnar cells. At *e*, flattened cells, called tessellated, are seen; *b*, basement membrane. P. is a papilla, or eminence covered with columnar cells.

Fig. 30.



What are the advantages of a capsular ligament?—How does atmospheric pressure add to the security of a joint? What is the intervertebral substance? How is it composed? Upon what does erectness chiefly depend? Describe fig. 30.

 Lubrication of joints—Epithelium—Secretory process.

129. *That the parts composing the joints may move upon each other freely*, it is necessary that they should be constantly lubricated with some glairy fluid. When a joint is opened, its surface may be seen covered with, usually, a very minute quantity of liquid, much more perfect than oil. It is mostly composed of water. A little albumen and a very minute quantity of several other substances are found in it. It has much the appearance that a teaspoonful of white of egg mixed in a quart of water would have.

130. *Upon further examination with a microscope, the inner surface of the joint* is found to be composed of minute cells, placed side by side, as represented at *e*, fig. 30. They have the appearance of minute bubbles flattened. They are filled with a fluid, and the interstices between them are filled with a thin gelatinous substance. Below this layer of cells, which is called epithelium, there is found a very delicate layer of substance spreading uniformly under the whole, and seeming to be a basement for the cells—hence called the basement membrane. *b*, fig. 30. Both these layers together are so delicate they cannot be seen by the naked eye; under the highly magnifying microscope they appear very beautifully. The fluid before spoken of seems to be formed by the action of one or both these layers. How it is formed is not now known. The process is called secretory, and the fluid is said to be secreted.

Some, however, suppose that the fluid passes into the joint upon merely mechanical principles, not being, properly speaking, secreted.

131. *The fluid is called serous*, also synovia, and synovial

With what is the surface of a joint covered? Did you ever notice it? What is the inner surface of the joints composed of? What is below the epithelium? What is the secretory process in a joint?

 Capillary vessels—Fibrous membrane—Compound membrane.

serous fluid. It is formed or comes from the blood, which must therefore be brought near to those layers before mentioned. If we look below the basement membrane, we shall find an abundance of blood, contained in a network of blood-vessels so minute that they cannot be seen by the naked eye. From their small size they are called capillary or hair-like blood-vessels. Fig. 31. Their sides are not thicker than the sides of a soap-bubble. Such delicate vessels must be carefully protected. We find, therefore, that they exist in the meshes of fibres interwoven so as to form apparently a dense membrane. Fig. 32. Some of these fibres are white, and

Fig. 31.

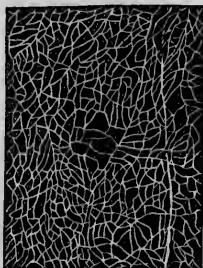


Fig. 32.



some yellow, the elasticity depending upon the proportions of these. Fig. 32. Leather is formed of this layer of the skin of an animal. It is called fibrous membrane.

132. *The fibrous, basement and cellular or epithelial membranes* together form a compound membrane, in this case called a serous membrane. It may be called a secretory apparatus. The last two may be called secretory tissue,

Where is synovial fluid found? Which is the generic term, serous or synovial? From what is synovia formed? What is found below the basement membrane? What parts form a compound membrane? What may it be called?

 Tableau of tissues of framework—Muscular tissues.

which I prefer. The following tableau presents the tissues of the framework.

The FRAMEWORK is composed of the $\left\{ \begin{array}{l} \text{Bony,} \\ \text{Cartilaginous,} \\ \text{Fibrous,} \\ \text{Secretory,} \end{array} \right\}$ Tissues.

133. *The muscular or contractile tissue* has different properties from any part of the skeleton. The tendons with which it is connected to the bones are formed of the white fibres. So also are the membranes which bind together the bundles of fleshy threads of the muscle, and also cover it as a sheath. The substance which exists between the muscles and skin or other parts of the body, is composed of white and yellow fibres which form large meshes communicating with each other, and called areolæ. The substance which forms them is hence called areolar tissue. It allows the parts to move upon each other without friction. The tendons must sometimes be bound in their places. This is effected by means of the same fibrous tissue, arranged in form of bands. (Plate 2.) Where there is liability to friction from the action of the tendons or in any such way that areolar tissue cannot prevent it, a little bag called a bursa is made use of. It is composed of a serous membrane, formed into a closed sac, the moistened sides of which lie against and move upon each other without the slightest friction.

MUSCULAR APPARATUS is composed of $\left\{ \begin{array}{l} \text{Muscular,} \\ \text{Fibrous,} \\ \text{Secretory,} \end{array} \right\}$ Tissue,

How many tissues are found in the framework? What is the property of muscular tissue? What tissue connects it with the bones? What is the use of areolar tissue? What prevents the friction of tendons? How is a bursa formed?

Synopsis of tissues—Tissues necessarily undergo changes.

134. *The nervous system is composed* only of the nervous tissue, there being required to preserve it in form and position a certain proportion of fibrous tissue, and to prevent friction certain arrangements of secretory tissue.

135. *The Organs of Sense are all composed* of the already mentioned tissues, which, indeed, possess all the properties that are required in any part of the body.

136. The following tableau gives a synopsis of tissues.

The APPARATUS OF RELATION is composed of	$\left\{ \begin{array}{l} \text{Osseous or Bony,} \\ \text{Cartilaginous,} \\ \text{Fibrous,} \\ \text{Secretory,} \\ \text{Muscular,} \\ \text{Nervous,} \end{array} \right.$	Tissues.
---	--	----------

CHAPTER V.

Tissues must be kept in repair—Useless substance removed—New substance deposited—Tableau.

137. *All the tissues*, but especially the nervous, muscular, and secretory, in the very act of being used, are becoming useless; no large amounts at any one instant, but a particle here and a particle there undergo changes which render them useless in the places which they filled.

It is indeed supposed, that no one particle of the tissues mentioned above can be used more than once; precisely how or why the changes take place is not known. But as the components of powder which has been burned are no longer powder, or of use as powder, so the components of the nervous or muscular substance no longer form the same compounds they did before use.

138. The useless particles must be removed, and the

Nervous apparatus is composed of what? What tissues are found in the organs of sense? How many tissues in the apparatus of relation? Which tissues change most rapidly? Do they undergo changes at once or gradually?

Excretion—Elimination—Requirements for the nutrition of the tissues.

places they occupied be taken by new compounds to undergo the same changes as their predecessors.

Some animals are so small, and of such a nature, that any useless substance can easily pass to the surface of their bodies, and thus pass away altogether, and substance can pass inward in the same simple manner; but in case of the larger animals such a simple arrangement is not possible.

139. *In the human system the removal of useless substance* would seem to require two processes. 1st. It must be removed from the place it encumbers; 2d, it must after that be cast out or eliminated from the body. The first process I shall term excretion; the second, elimination.

As substance is to be excreted by all parts of the body, there must be some means of withdrawing the substance from all parts. In the first place, a series of tubes might be placed in all parts, the tubes being so minute that useless substance might pass into them from all the minute spaces between them in the same manner as in case of the small animals spoken of. Larger tubes might open from these, and gradually uniting, at last bring all the substance together or into several places, where it could be acted upon, and if any thing of use was found, it could be appropriately disposed of, and what was worthless could be eliminated.

140. *In the human system the renewal or nutrition of the tissues* would seem to require, that substance should be prepared, taken into the body, carried to every part, and deposited in accordance with its wants.

In case of the small animals mentioned, the food adapted to their wants is directly about them, and already prepared for their use. If what may be called food for the tissues, that is, substance prepared for their immediate nutrition, could be introduced into the minute tubes before mentioned, it would be so near the tissues they could easily obtain it. Indeed, it would then have the same relation to the tissues that the substance outside the little animal

In what way is substance removed from some small animals? For removal of useless substance from the human body what two things are required? How could substance be withdrawn from all parts of the body?

 Synoptical tableau of Repairing Processes—Preservation of Temperatures.

has to its tissues. If a set of larger tubes communicated with the minute ones, and some force existed to press the nutritious substance on, all that would be wanted would be the prepared nutrition and its introduction into the large tubes.

141. The following tableau presents the subject of systematic repair synoptically.

The process of repair requires, { That useless substance be removed.
That new substance be deposited.

To remove useless substance three processes { Excretion,
are necessary, { Circulation,
Elimination.

To renew the tissues, at least four pro- { Preparation of food,
cesses are necessary, { Absorption,
Circulation,
Nutrition.

 CHAPTER VI.

Body must be kept at healthful temperatures—Heat produced, circulated, preserved, and removed—Tableaux.

142. *That the tissues may exhibit their properties*, it is necessary that they be kept at healthful temperatures.

143. *To raise the temperatures of the body*,

HEAT must be - - - { Produced,
Circulated,
Preserved.

144. *To lower the temperatures*,

HEAT must be { Prevented from being produced,
Neutralized,
Removed.

When we wish to produce heat under ordinary circumstances,

If nutrition were prepared and introduced into the large tubes, how could it be led to the tissues? What does the process of repair require? What processes remove useless substance? What are necessary to renew the system? To raise and lower temperature of the body, what are necessary?

 Production and Circulation of Caloric.

we cause oxygen and carbon or hydrogen, or both to unite, when heat is given off; and also carbonic acid produced in the first case, and water in the last.

Illus. a.—When coal, which is, except ashes, composed of carbon, is burned, oxygen and carbon unite.

Illus. b.—Wood is composed of oxygen, carbon, and hydrogen. When wood is burned, the oxygen of the wood unites with its hydrogen; heat and water are produced, while any surplus oxygen with oxygen from the air unites with the carbon.

Illus. c.—When a coalpit is made, the access of the air is prevented, and there is not oxygen enough to unite with the carbon which remains as coal.

Illus. d.—When the oil of a lamp or substance of a candle is burned, the same process takes place as when wood is burned; the oil, tallow, wax, &c. being composed of oxygen, carbon, and hydrogen.

145. *Heat may be produced* in the human system by having oxygen unite with carbon or hydrogen, or both.

Heat might be first produced and then circulated, or the materials by which it can be produced might be first circulated, and the heat then produced in all parts; or both plans could be combined, which would be the best. The substances which become useless as tissues, are found upon examination to be composed of oxygen, carbon, and hydrogen. Hence, if oxygen could be circulated in the minute tubes before mentioned, it would easily act upon any surplus carbon and produce heat and carbonic acid. For such a purpose, the two sets of large tubes before mentioned would be necessary, and also some means for causing the oxygen to enter them. If a sufficient amount of heat were not thus produced, more oxygen, carbon, and hydrogen must be introduced.

146. *Heat might be circulated* through the body by having a current of fluid constantly flowing here and there, which would take heat from one part and yield it to another.

How do we ordinarily produce heat? What is the effect of burning coal? Wood? Oil? How may heat be produced in the human system? If oxygen be circulated through the system, what will be the effect? How may heat be circulated?

Heat Preserved, Prevented, Removed—Tableau of apparatus and substances required by the Body.

147. *Heat must be preserved* by surrounding the body with non-conducting substances.

148. *The production of heat can be prevented* by avoiding exercise that causes a rapid change of the tissues, absorption of oxygen, and circulation in the system.

In respect to neutralizing heat, all that can be said is, that persons take acids in warm weather, and with apparent profit.

149. *Heat may be removed* from the body, or any thing, by evaporation of fluid from its surface.

That this evaporation might go on, it would be simply necessary that water should be introduced into the large vessels or tubes already mentioned; through these it could be forced into the minute tubes or vessels of the skin, thence exude to the surface and evaporate.

150. The same general apparatus and substances seem necessary to keep the body in repair and to regulate its temperature, as shown by the following tableau:—

To keep the tissues in repair and at proper temperatures, there are required—	{	Water;
		Food;
		Oxygen;
		A tubular and forcing apparatus to circulate the water, food, and oxygen;
		An apparatus to prepare the food and introduce it into the tubular;
		An apparatus for introducing water;
		An apparatus for introducing oxygen;
		An apparatus for elimination;
		Clothing.

How may heat be preserved? How is the production of heat prevented? How may heat be removed from the body? How can evaporation from the skin be carried on? What substances are necessary to keep the body in good condition? What apparatus?

CHAPTER VII.

Water, Food, Oxygen, and Clothing—Circulating, Respiratory, Digestive, Eliminatory, and Nervous Apparatus necessary—Tableaux.

151. *Water* is one of the most variously useful of substances found in the body. 1st. It is necessary in the composition of the tissues. 2d. It serves as a means or vehicle of transportation from one part of the body to another—*a*, of the useless substance produced by the action of parts; *b*, of the nutritive substance which is to renew the tissues; *c*, of the oxygen which is to produce heat or serve any other purpose; *d*, of heat, receiving it from one part and yielding it to another. 3d. By exudation and evaporation it removes heat, and also assists in the elimination of all waste substances.

The rapidity with which all processes take place in the body should vary very much at different times; e. g., at one time the water should transport much more nutriment to, or remove more waste substance from a part, than is necessary at another. Now, this could be accomplished either by diminishing the quantity of water, or increasing the rapidity of its motion, or by both means together.

Illus.—If there be twenty pounds of water and nutritious substance together, of which two are nutrition, and the whole move through a given space at the rate of four pounds per minute, the whole would pass the space in five minutes, and the two pounds of nutriment, of course, in the same length of time. If we remove four pounds of water, then the whole will pass the space in four minutes, and the two pounds of nutriment in the same time. If, instead, we add four pounds of water, the two pounds of nutriment will be six minutes in passing the space, which may be considered as representing the entire body.

What are the uses of water? Should each process take place with the same activity at all times? How could the activity of the process be regulated? What would be the effect upon the circulation, of increasing the water in the blood four lbs.?

 The activity of Functions regulated by Water—Food a Nutrient.

152. *The quantity of water* in the system affects the rapidity with which all the processes in it take place, and this is one of the most important things for every person to consider.

There should be some means by which the quantity of water should be regulated. For this purpose it must be at times added to, and sometimes removed from the system. Water is, therefore, sometimes to be considered a waste, useless, or even injurious substance in the body—hence it is to be eliminated as any other waste substance. If it exude through the skin and evaporate, it removes heat, and this is not desirable when we wish to elevate the temperature of the body. There must, therefore, be at least two eliminating organs by which water can be rapidly removed. If we consider, we shall be surprised to observe that when it is necessary to remove or add water for one purpose, every process is facilitated; e. g., if any part requires nutriment in large quantity, there is also much waste to be carried from it, and, of course, to be eliminated. When, therefore, on any one of these accounts the water is to be diminished, so it is on account of all of them. When water should be added, the want should be indicated to the mind by a sensation which will draw its attention, as it is the purveyor of the body. Hence the advantage of thirst.

153. *The less the quantity of water* in the system (within proper bounds), the more rapidly all processes take place, except the removal of heat.

When heat is to be rapidly removed, the other processes should not and cannot take place rapidly.

154. *Food* serves as nutriment to the various tissues.

As the tissues are very different in constitution, it could not be expected that one kind of food, except it was very complex, would be equally good for all of them. The student, who decomposes his nervous system very rapidly, would, therefore, require different kinds of food from one who uses his muscular tissues to a corresponding degree. There must be different kinds or varieties of nutritious food.

How does the quantity of water affect the activity of animal functions? What is the effect of removing water through the skin? What is the effect of diminishing the quantity of water in the system? Should all persons live on similar food?

 Nature of Food—Oxygen.

155. *Food also* assists in the production of heat.

That this is true, is proved, 1st, by the fact that it is required. Heat sufficient for the wants of the body could not at all times be produced from the decomposed tissues alone. 2d. Certain kinds of food are composed of oxygen, carbon, and hydrogen only, which substances have already been shown to be adapted to the production of heat. 3d. These kinds of food are eaten in much larger quantities in cold than in warm weather.

156. *Some kinds of food* are cooling.

The most that can be said upon this point is, that acids are very refreshing in hot weather, and are most abundant then.

157. *Some kinds of food* are useful merely by their bulk.

When the digestive organs are reasonably distended, they can act more easily upon their contents than when containing but a small portion of substance.

Illus.—A person can grasp in the hand a stick of reasonable size better than a little one.

158. Food may, therefore, be regarded as a generic term. Of it there are several species, as follows:—

Food	{	Nutritious, Calorific, Cooling, Waste or bulk.	}	Of each there are varieties.
------	---	---	---	------------------------------

159. *Oxygen* is a simple substance composing about one fifth of the atmosphere. It is of use in the body: 1st, in causing or assisting to cause the changes which constantly take place in all parts of the body; 2d, in producing heat.

It may be useful in preparing the food for use in the various parts of the system. It is a component of every kind of food.

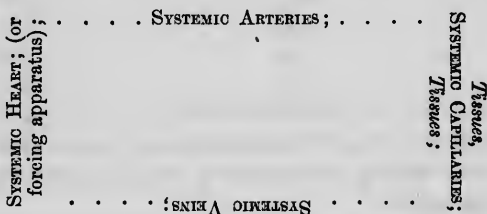
160. *A circulating apparatus is needed* for the purpose :

What part of food is useful in producing heat? What substances do we use in warm weather more than in cool? How many species of food are there? What are the uses of oxygen in the body?

Provisions for eliminating waste substance from the Body.

1st, of gathering the waste or useless substance from all parts of the body, and transmitting it to eliminating organs. 2d, of receiving and circulating the food and oxygen. It must of course be constructed accordingly.

We have already seen that three kinds of tubes, and an organ to force substance through them, would be needed in removing waste substance from, and transporting nutritious substance to the tissues; as shown by the following tableau. See also Plate 5, where the systemic arteries and veins are represented.

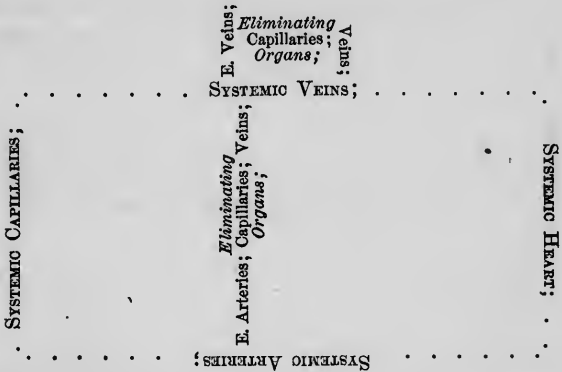


But three other things are to be provided for: 1st, the elimination of the waste substance; 2d, the introduction of food; 3d, the introduction of oxygen. The first object could be accomplished by having some branches of the arteries to lead some of the blood to organs adapted to eliminate. True, some of the substance must pass round many times before it would happen to reach the eliminating organs; but that would be of no consequence, provided it was eliminated as fast as it was produced. Such an arrangement exists in some animals which do not suffer from the accumulation of certain kinds of waste substance to a greater degree than would be consistent with the health in man, whose activity renders him more sensitive to the action of waste substance.

161. *To circulate the waste substance to eliminating organs*, branches of the systemic arteries lead to the minute capillaries of eliminating organs, as shown by the following tableau:

What are the purposes to be served by a circulating apparatus? How might substance be eliminated? Could all waste substance be eliminated by one circulation? How might eliminating substance be circulated to proper organs?

Provisions for eliminating waste substance from the Body.



Also, there may be, as represented by the tableau, branches of the veins leading to eliminating organs, or both arrangements may exist.

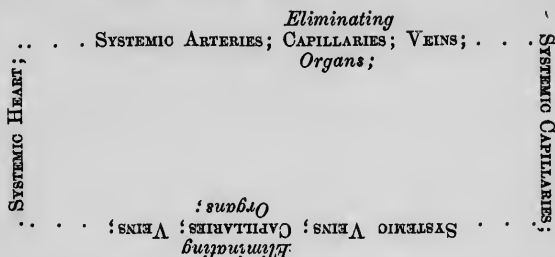
But, as the tissues are numerous, and composed of some different elements; it would be natural to suppose that the excreted substances would differ from each other in their nature and quantities. If the accumulation of any of them should be detrimental to the tissues, they must be removed before they return to the tissues.

Illus.—If one half of the blood should pass through an eliminating organ which removed every particle of waste substance it received, and if there were two ounces of it produced in a given time in the tissues, the amount in the vessels would increase to four ounces, before the organs would remove it as fast as produced, as they would then receive but two ounces in the given time.

162. An arrangement may be made, by which all the substance which leaves the tissues shall pass through eliminating organs before it returns to the tissues, in either of the ways exhibited by the following tableau :

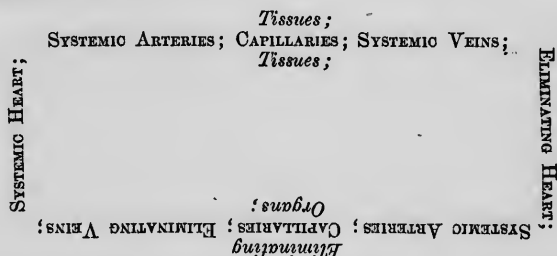
Can the blood flow through the veins to eliminating organs? Is the same kind of waste substance produced by all the tissues? If one half the blood pass through an eliminating organ what will be the effect?

Provisions for eliminating waste substance from the Body.



But if the apparatus were extensive, and it were necessary that the substance should pass their rounds rapidly, one heart would not be sufficient; for if it were large and strong enough, it would seriously injure the nearer delicate capillaries.

163. If the waste substance must be rapidly removed, and as fast as it is produced, a second heart must be introduced, as follows :



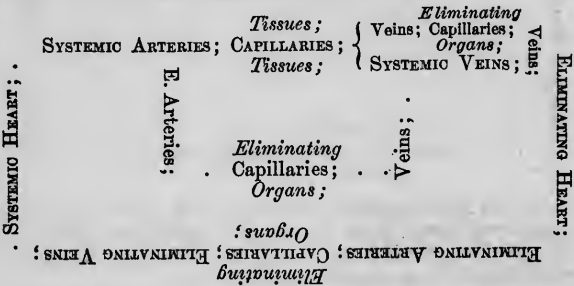
If a heart be introduced, the arteries which lead from it will be also necessary, as veins are not suitable for the force the heart exerts. But, as the waste substances differ from each other, it is not probable that this arrangement alone would be sufficient in all cases. The previous tableaux have represented what will be found in various animals, and is sufficient in them.

164. The arrangements exhibited under ¶ 161 and 163

What arrangement can be made to have all the waste substance pass through an eliminating organ before it returns to the tissues? Would one heart be sufficient in such a case? If another heart be introduced, what else will be necessary?

Tableau of Circulating Apparatus.

may be combined, as shown by the following tableau. It exhibits the arrangement in the human body.



If this arrangement should not be sufficient, other hearts must be added, and the circle made more extensive. No animal is known, which requires a more complicated apparatus than this.

The following tableau will represent in another view, the requirement for a human circulating apparatus.

- TWO HEARTS. { Systemic (called also left).
Eliminating (called also pulmonary and right).
- TWO CLASSES OF ARTERIES. { Systemic.
Eliminating (called also pulmonary), and branches of Systemic.
- TWO CLASSES OF CAPILLARIES. { Systemic, some of which are eliminating.
Eliminating (called also pulmonary).
- THREE CLASSES OF VEINS. { Systemic.
Eliminating (called also pulmonary).
Portal.

165. For the reception of nutrition, water, or oxygen, no new kind of parts will be needed by the circulatory apparatus.

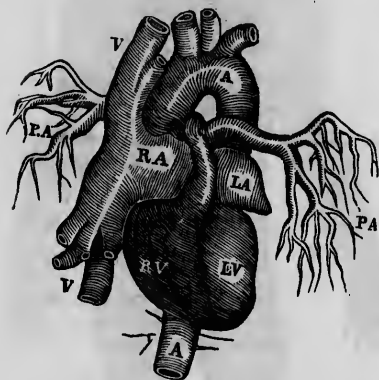
The minute capillaries are of such a character, that substances can easily pass through into them, as well as out from them. In the same manner, indeed, as the waste substances in the tissues enters them, so may water, nutriment, or oxygen, all that is

Describe the course of the blood according to tableau. What is needed that water, food, and air may pass into the blood-vessels? Describe Fig. 82. Where should the hearts be placed? Describe Figs. 34, 35, 86.

View of the Hearts of Man and the Dugong.

needed, will be some bags, or pouches, for containing the water, food, and air. The pouches must be very delicate, that the capillaries may be near the surfaces with which the water, food, and oxygen, are brought in contact. Substances can and do pass through the thick outer layers of the skin, and enter the capillaries which in part compose its inner and lifeful layer. But the external part of the skin is protective, and therefore must not be readily permeated. Tubes may also open into the arteries or veins, and thus substances could find their way into the circulation.

Fig. 33.

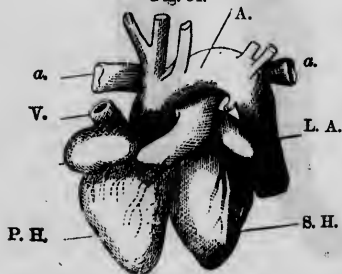


The two hearts in contact, as is natural. R A and R V form one; L A and L V form the other. V V are veins opening into R A. P A are arteries which lead out from R V. A are arteries opening from L V. The veins which open into L A are not represented.

167. *Each heart requires* the protection and assistant action of the chest. The same place which is favorable for one is equally

so for the other. They are therefore situated side by side, and externally appear to be but one thing, as in Fig. 33.

Fig. 34.



In some animals, as in the Dugong, the heart can be easily distinguished externally. Fig. 34.

S. H. Systemic or Left Heart. P. H. Pulmonary or Right Heart of the Dugong. A. Systemic Artery. a. Pulmonary artery. V. Systemic vein.

168. The systemic arteries must therefore lead out

View of large Human Systemic Arteries—Capillaries of Frog's Foot.

from, and the systemic veins concentrate at the chest. See Fig. 35, representing the largest arteries. The arteries terminate in the extensive network called the capillaries, as represented in Fig. 36, a magnified view of the circulation in a frog's foot as beautifully seen under the microscope. The veins open from the

Fig. 35.



Fig. 36.

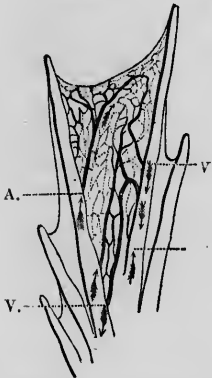


Fig. 36.—A. arteries, V. veins. Vessels between them, capillaries.

 Lymphatics—Oxygenating Apparatus needed.

capillaries, and leading back blood to the chest, open into the Pulmonary Heart.

169. In addition to the blood-vessels, there is a class of tubes of small size and peculiar structure containing lymph, and hence called Lymphatic vessels. The necessity which requires them, or their use, cannot yet be given with certainty. They exist in nearly all parts of the body in great numbers (see Pl. 4), and open into the veins. There are, therefore, four kinds of vessels or tubes in the body:—Arteries, Capillaries, Veins, Lymphatics.

170. As all the processes by which the tissues are kept in repair and of a proper temperature depend upon a proper circulation of the contents of these vessels, the action of the heart, and of whatever else affects the circulation, is of the greatest importance to the welfare of the whole body.

171. *An apparatus is needed* to allow the oxygen of the air to act on the tissues.

In some animals, tubes lead from the surface of the body into various parts of the body, and the air can pass through these into the immediate vicinity of the tissues, in the same manner as the blood can by means of the blood-vessels. But as the oxygen of the air is all that is needed in man, it will be better to have it unite with the blood, and with it be circulated through the tissues.

172. *For the purpose of having the oxygen act upon the tissues*, three things will be necessary:—The air, which is composed in part of oxygen, must be brought in contact with the blood constantly, unite, and be transported, with it.

The carbonic acid with which the blood is constantly loaded by the action of the tissues must be eliminated by the assistance of the air, as already shown. Consequently, in the extensive class of

How many kinds of tubes exist in the body? What are lymphatics? What is of great importance to the welfare of the body? How is it best to have oxygen carried to the tissues? That oxygen may act upon the blood, how many and what things are necessary?

 Things to be considered in the process of Respiration—The Chest.

eliminating capillaries through which the blood circulates to be purified of the poisonous carbonic acid, will be precisely the place where the oxygen of the air can have ready access to the blood. As the surface through which the oxygen acts, or the carbonic acid escapes, must be very delicate, it must not be any exposed external surface of the body. The best arrangement would be, to have a pouch, and some means by which the air could be inhaled and exhaled. The oxygen needs no preparation; therefore the pouch may be very simple. The movable chest has been already contrived as a speaking apparatus, so as to inspire and expire air. If, then, a pouch or pouches were suspended in the chest and connected with the windpipe, the action of the chest will cause breathing.

173. In the process of respiration five things are to be considered: 1st. The character of the atmosphere. 2d. The structure and action of the chest. 3d. The structure and action of the lungs. 4th. The action of oxygen upon blood. 5th. The elimination of carbonic acid.

174. The respiratory apparatus is composed of—1st. The chest. 2d. The lungs.

175. The lungs are concerned in two important duties, and perhaps a third:—1st. Elimination. 2d. Calorification. 3d. Nutrition (?).

176. The chest is chiefly occupied by four organs—the hearts and lungs.

177. The chest is composed of its framework—12 vertebræ, 24 ribs with their cartilages and the sternum;—of the muscles of inspiration and expiration, including the diaphragm; and of its lining, the pleura, (see Fig. 37), which also divides the chest into three parts, the right, left, and central cavities—occupied by the right and left lungs and by the hearts. The double partition of pleura is called mediastinum.

What kind of a place is required that the air and blood may freely act upon each other? What five things are to be considered in the process of respiration? Of what is the respiratory apparatus composed? In what processes are the lungs concerned?

View of Chest—Composition of Lungs—Water needs no Preparation.

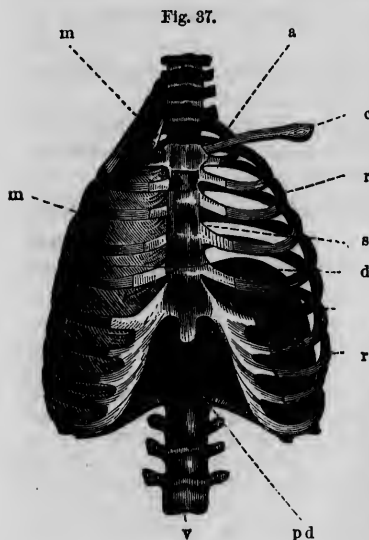


Fig. 37.—View of 'the chest. On the right side the frame alone is seen. *v*, Vertebrae. *a*, First rib. *c*, Clavicle or collar bone. *r*, Ribs. *s*, Sternum or breast bone. *d*, Diaphragm, which arches up within the ribs. *p d*, Pillars of diaphragm. On the left side the intercostal (rib) muscles are shown.

In some animals the lungs are simple pouches; but in man and the higher animals it is desirable to have as much air and blood act upon each other as is possible in a small space.

178. Human lungs are essentially composed of millions of small pouches, or air-cells, of tubes which open into these,

and of blood-vessels. In addition, however, there are nerves, lymphatics; and a covering, the pleura.

179. The lungs are filled by the enlargement of the chest, when the air rushes in to fill the lungs and prevent a vacuum between them and the chest. When the chest is diminished, the elasticity of the lungs usually expels the air.

180. *Water does not need any preparation* before it enters the blood. A very simple pouch is all that is required for it.

If taken into the mouth when a person is thirsty, it passes into

Describe fig. 37. What in some animals is the simple form of the lungs? Of what is the chest composed? How are the lungs filled? Why does not water need any preparation? What is required for the reception of water?

View of the Stomach—Its adaptation to receive Water.

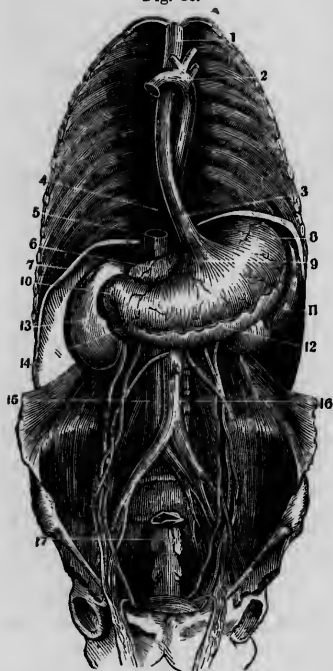
the blood, but not so rapidly as is desirable under ordinary circumstances.

Inf. a.—If a person is sick and pained by swallowing, sufficient water can sometimes be absorbed from the mouth alone.

Inf. b.—If a person be very thirsty in a hot day, the edge of the thirst may be taken off by holding water in the mouth, and he will not afterward be so likely to drink too much.

181. A pouch, the sides of which could produce gentle

Fig. 38.



pressure on its contents, would be best adapted for the reception of water.

A pouch continuous from the mouth and surrounded by muscles would answer the requirement. But the chest is occupied, and no convenient place can be found nearer than below the diaphragm. A long tube will be required to reach it. See fig. 38.

1, 3. Œsophagus. 2. Artery. 4. Spinal column. 5. Vein. 7. Diaphragm. 8. Large extremity of stomach. 9. Connection of Œsophagus and stomach. 10. Small or pyloric extremity of the stomach. 11. Spleen. 12. Attachment of the omentum or caul. 13. Kidney. 14. Duodenum. 15. Vein. 16. Artery.

182. The mouth, œsophagus, and stomach constitute an apparatus for the reception of water; and

What are the advantages of holding water in the mouth?

Passage of Water into the Blood-vessels—The preparation of Food.

three things are to be considered: how it is taken into the mouth, swallowed, and passed from the stomach into the blood-vessels.

183. By the action of the breathing apparatus, the mouth can be exhausted of air and filled with water, which is then passed back into the throat. It does not thence fall by its gravity, but by the action of the muscular rings which in part compose the œsophagus, it is swallowed into the stomach, which is thereby distended correspondingly. Near the inner surface of this a multitude of capillaries may be found, and if water is needed they absorb it from the stomach with wonderful rapidity.

184. The processes by which the food passes into the blood-vessels is equally simple with those previously mentioned. But the food must first be prepared to enter the blood-vessels.

185. Food is not a simple substance like oxygen, or a simple compound like water, but is composed of many elements highly compounded. The first preparation which the components of food undergo is in the physical world; then the vegetable still more highly compounds what it obtains from the inorganic world. Food is thus produced. Sometimes it is eaten without, but usually after, cooking. In either case it must be masticated and mixed with saliva. This takes place in the mouth. It must then be mixed with, and acted upon by, a fluid which can be conveniently formed in the sides of the stomach, which is also a very appropriate pouch for retaining the food while it is acted upon.

What three things are to be considered in respect to water? How is water passed into the blood-vessels? What compounds food for the use of animals? After cooking, what processes must food pass through?

 Absorption of the useful parts of Food.

186. If any of the food becomes in the stomach fit to pass into the blood, the capillaries are ready to absorb it. The rest must be subject to the action of two other fluids, called pancreatic and biliary. The first is formed in a small organ just back of the stomach, called the Pancreas. The last is found in the biliary apparatus, which consists of the liver and gall-bladder. From these organs the fluids flow into the upper part of a long tube called second the stomach, which has this form evidently for the purpose of presenting much surface to the action of its contents.

187. After the food has been prepared in the stomach, it passes into the second stomach, through the opening called pylorus, (Fig. 39.) There it receives the action of new fluids, which still farther prepare it and adapt it for forming a part of the blood.

188. When substance in the second stomach is fitted to become blood, there are two channels by which it may reach the circulation. 1st. It may pass into the capillaries, which in great numbers exist near the inner surface of the second stomach. 2d. It may pass into a distinct set of vessels, which also commence very near to the surface. They are called lac-

Fig. 39. A. 1, 2, skull; 3, cervical muscles; 4, chin; 5, frontal sinus; 6, middle, 7, inferior turbinated bones; 8, middle, 9, inferior meatus; 10, roof of mouth and floor of nose; 11, opening into Eustachian tube; 12, anterior cartilage of vomer; 13, muscles of tongue; 14, soft palate; 15, curved rod, the inner extremity of which is at 11; a, cerebrum, b, cerebellum, c, medulla oblongata and meso-cephalon.

B. 14, 15, cesophagus; 16, 17, 18, 19, 20, stomach open; 21, cardiac orifice; 22, pylorus; 23, 24, 25, 26, duodenum open; 27, 28, gall cyst; 29, 30, 31, bile and gall ducts; 32, their outlet; 33, pancreatic duct; 34, its outlet; 35, 36, second stomach entire; 37, 38, open; 39, outlet into 40, 41, cæcum; 42, vermiform appendage; 53, ascending, 44, 45, 46, transverse, 47, descending colon open; 48, 49, sigmoid flexure; 50, rectum.

Fig. 40. 1, 2, 3, aorta; 7, 8, 9, 10, veins; B. lacteals; 12, receptaculum chyli; 13, thoracic duct; 14, its opening into the veins at the angle 9.

How does any food pass from the stomach into the blood-vessels? To what fluids is the food subjected when it passes from the stomach? Why is the second stomach a long tube?

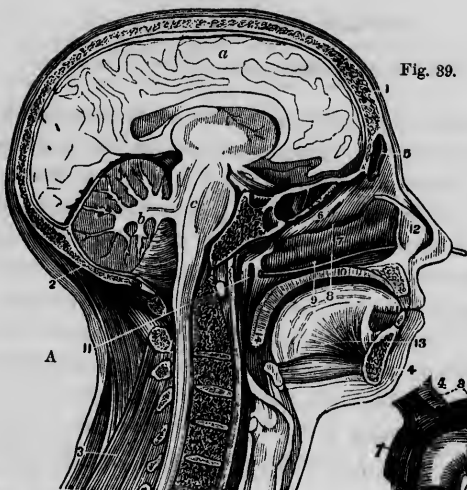


Fig. 39.

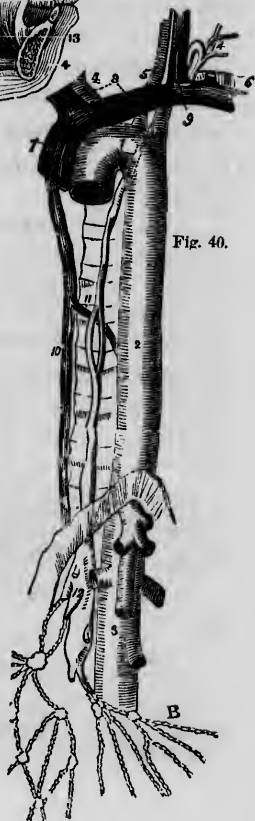
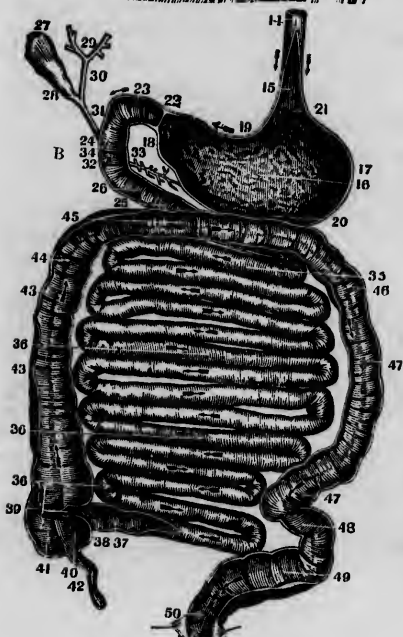


Fig. 40.

Requirements for Eliminating Organs—Surface of Skin increased.

teals, but seem to be a branch of the lymphatics, and are to be classed with them. They open into the veins, into which they pour their contents to be mingled with the blood. The remaining portion of substance passes through the entire length of the second stomach to be deposited in the colon. The substance may be really waste, or it may be valuable, but not prepared to become blood, and therefore waste.

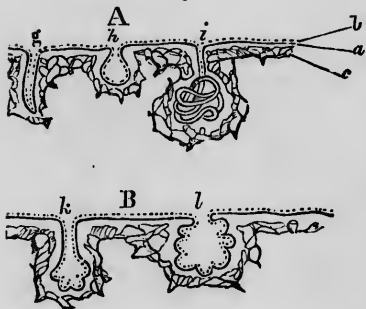
189. *The entire apparatus adapted to prepare the food* for reception in the blood-vessels, is called digestive, and includes the mouth (teeth, salivary glands, tongue and other muscles), œsophagus, stomach, second stomach (duodenum, jejunum, and ileum), pancreas, liver, gall cyst, lacteals, and colon (?).

190. *That any organ may eliminate* substance from the blood, three things are necessary. 1st. It must receive blood. 2d. Have the property of eliminating. 3d. Have communication with the surface of the body.

191. *The skin* answers all these requisites, and it is to be reckoned as a very important eliminatory organ.

To increase the extent of surface of the skin, and of course to

Fig. 41.



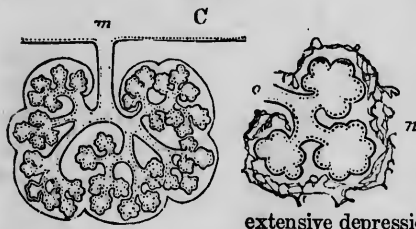
increase its eliminating power, it is formed into numerous tubes, some shorter and some longer, called cryptæ, follicles, and simple glands, as the case may be. The following figures show how surface may be increased, A, B, C, D, being similar but more and more compound ways of securing the same end: the increase of surface in a small cubical space. In E and F the same end is gain-

The Skin, Lungs, Liver, and Second Stomach, Eliminating Organs.

Fig. 43.

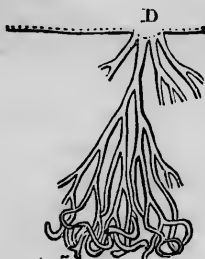


Fig. 44.



ed by both depressions and elevations; indeed, to increase surface in a small cubical space, it will be found that one or both these means are used throughout the body. Fig. 47, *ab* represents a rudimentary salivary gland. The perfect gland is made upon the same principle, as part of one shows, Fig. 48.

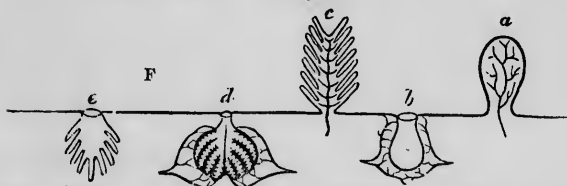
Indeed the lungs are merely two great glands, formed by an extensive depression of the skin.



192. *The lungs* answer to all the requirements of an eliminating organ, and are to be considered of primary importance as eliminating organs.

193. *The liver and second stomach*, including the colon, answer the requirements of, and may be considered as, eliminating organs.

Fig. 46.



In figs. 41 to 46, the dotted line represents the surface of the skin, viz., the cellular or epidermic layer or membrane; *a* represents the basement membrane; *c*, the network of vessels that occupy the meshes of the fibrous membrane.

Eliminatory Glands—Kidneys important Eliminating Organs.

Fig. 47.

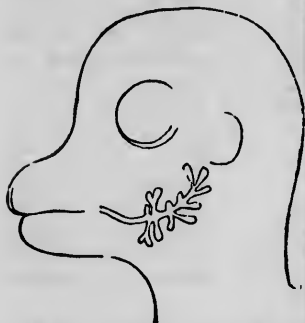


Fig. 47. *a* represents the opening of a tube leading from the cheek to the cryptæ *b*.

Fig. 48.



Fig. 48. Compound gland. *a a* tubes leading to the cryptæ *b*. Blood-vessels are seen by side of *a*.

194. *The kidneys* are very important eliminating organs, since they can very rapidly remove water from the vessels, and thus accelerate all the processes by which the body is kept at a proper temperature, and in perfect repair.

It is sometimes thought that the salivary glands, pancreas, and even the gastric glands are organs of excretion, as well as the liver and nail follicles. No doubt the blood is the better for the action of these parts of the body; but as the saliva, gastric juice, and pancreatic fluid are useful in operations of digestion, it is hardly proper to call them eliminators, though there is no particular objection to doing so. The substances spoken of are, in fact, eliminated from the blood and from the body, properly speaking, though taken back under new forms.

195. The eliminating apparatus is composed of five or

Describe figs. 41 to 46. Why may the lungs be considered eliminating organs? Why may the liver and second stomach be so considered? Describe figs. 47 and 48. In what respect are the kidneys very important eliminating organs?

Tableau of Circulatory, Respiratory, Digestive, and Eliminary Apparatus.

gans, as in the following tableau, and they are useful in removing waste substance from the body, including heat and water, and thereby regulate the temperatures, repair and health of the tissues.

ELIMINATING APPARATUS, { SKIN,
LUNGS,
LIVER,
SECOND STOMACH,
KIDNEYS.

196. A review of the circulatory, respiratory, digestive, and eliminatory apparatus will present the following tableaux.

CIRCULATORY APPARATUS,	{	HEARTS,	{	SPLEEN, THYROID, THYMUS, AND SUPRARENAL GLANDS.
		ARTERIES,		
		CAPILLARIES,		
		VEINS,		
		LYMPHATICS.		

RESPIRATORY APPARATUS, { CHEST FRAMEWORK,
RESPIRATORY MUSCLES,
PLEURA,
LUNGS.

DIGESTIVE APPARATUS,	{	MOUTH,	{	TEETH,
		ŒSOPHAGUS,		SALIVARY GLANDS.
		STOMACH,		
		SECOND STOMACH,		
		LIVER,		
		PANCREAS,		
		LACTEALS,		
		COLON.		

ELIMINATING APPARATUS,	{	Special,	{ SKIN,
			{ KIDNEYS.
	{	Secondary,	{ LUNGS,
			{ LIVER,
			{ SECOND STOMACH AND COLON.

How many organs are adapted to eliminate waste substance from the blood? Of what organs is the circulatory apparatus composed? The respiratory? The digestive? The eliminating?

Review of the reasons for the existence of Circulatory, Respiratory, Digestive, and Eliminary Apparatus.

If we now review the necessities for these several kinds of apparatus, we shall distinctly perceive, that as the whole body is so large that substance applied to its surface could not readily make its way into the midst of the tissues except after a very long time, it was necessary to devise some means by which substance could be brought into the immediate vicinity of very minute parts. For this purpose an immense number of tubes were extended through every part of the body, and a forcing apparatus connected with them (Plate 5). These tubes were not less important in allowing all useless substance to be removed from the tissues. It must be seen, and distinctly remembered, that what is in these tubes is not, properly speaking, in the body, but on the outside of the parts to be nourished. The contents of the tubes is the nourishment. If these tubes should open from the surface of the body, there would be no difficulty in understanding this. It is all the same if the tubes form a complete circle. How shall the contents of those tubes be prepared and passed into them? It might be supposed that they could be prepared out of the body, and injected by means of a syringe. This is sometimes done. The blood of an animal is drawn, and by a syringe is carefully injected through an orifice made for the purpose into the vessels of an animal of the same species with the same results as when the substance enters in the ordinary way. But the oxygen needed in the blood exists abundantly in the air, in the midst of which we constantly live—and which we must use in speaking. Therefore, without any inconvenience a person may every moment introduce the oxygen, which needs no preparation, and save all trouble of introducing it at any one time and having it in the vessels in larger quantity than is needed at the time. The chest must exist for other reasons, and its cavity may be advantageously occupied by the lungs, since they will assist a person in lifting, and in various ways. The quantity of water needed varies very much under various circumstances. It is made, therefore, very abundant, and with the slightest trouble we can pour or swallow into a portable pouch a small supply, that will, as needed, pass into the vessels. This pouch occupies a space which necessarily exists in the body for other reasons. Food must be prepared. The utensils for cooking it are too cumbersome to be portable. The kitchen is a fixture. But after the food has been cooked, a small portion may be taken into the body for farther

Why is it necessary to devise means for bringing substance into the immediate vicinity of every minute part of the body? Is substance which is in the blood-vessels properly speaking in the tissues?

 Apparatus of Organic Life.

preparation, after which it can be passed into the vessels. Several hours are required for this preparation. What we eat does not, therefore, immediately nourish the tissues. Strictly speaking, the food we eat is not nourishment; nourishment is contained in food, which, however, must be prepared before it is fit to become blood. The food itself does not, therefore, pass into the body, strictly speaking; that is, it does not pass into the tissues. What is in the mouth, stomach, or second stomach, is outside the tissues; and when the nourishment passes into the blood-vessels, it is not yet in the body, or in the tissues, but outside them. If a large vessel opened from the stomach into an artery or vein, so that there was a direct and free passage, there would be no difficulty in understanding the idea. We carry with us, then, a small advance supply of food, and prepare it without inconvenience. A smaller store of water can be taken, while the air we breathe suffices only for the present moment.

197. Several different views may be taken of the blood. It is composed to a great degree of water. It is also composed of substance adapted to produce heat (and sometimes, perhaps, of substance adapted to cool the tissues), to nourish the tissues, and of waste substance. It is compounded from water, food, oxygen, and the decomposed substance of the body.

 CHAPTER VIII.

Apparatus of Organic Life—Nervous system necessary—Tissues—Tableaux.

198. The apparatus described in the last chapter, has a common purpose, viz., to preserve the body in a condition proper for action. The several kinds are properly grouped into a grand class of organic or vegetative life, as the following tableau exhibits:

How long after food is eaten before it becomes part of the tissues? Why does it immediately satisfy and seem to strengthen? Of what is blood composed? What kinds of apparatus does the apparatus of organic or vegetative life embrace?

 Tableau of apparatus of Organic Life—Its Tissues.

199. Different parts of this class of apparatus are muscular, therefore a nervous apparatus will be necessary to excite contraction of the muscles. Also, the action of the different parts must be made harmonious; therefore, all of them must be united with a common centre, upon which influences shall be exerted, and from which they shall be received by all.

THE APPARATUS OF ORGANIC LIFE INCLUDES THE	{	CIRCULATORY, RESPIRATORY, DIGESTIVE, ELIMINATORY, NERVOUS.
--	---	--

200. The various parts of the organic apparatus are composed of the same tissues as that of relation, with the exception of the bony. The cartilaginous is, however, required in very small quantity. The fibrous is very abundant. The muscular in medium quantity. The nervous is small in quantity. The secretory is in larger proportion than any.

201. *The surface of the skin* must be composed of secretory tissue. So also must the inner surface of the lungs, mouth, stomach, &c. The lungs, heart, stomach, and several organs must be suspended in the cavities they occupy, and their outer surfaces must be composed of secretory tissue, as well as the surfaces of the cavities in which they are. See Fig. 49.

202. Thus the surfaces which touch each other being free, and lubricated by serous fluid, glide over each other without causing any friction, and all the various motions of the trunk may take place, without in the least endangering the very delicate internal organs.

Why is a nervous apparatus necessary as a part of the organic? Of what tissues is the apparatus of organic life composed? Of what kind of tissues is the surface of the skin composed? What kind of tissue must exist at the surface of the lungs?

Serous Membranes of the Abdomen.

Fig. 49.

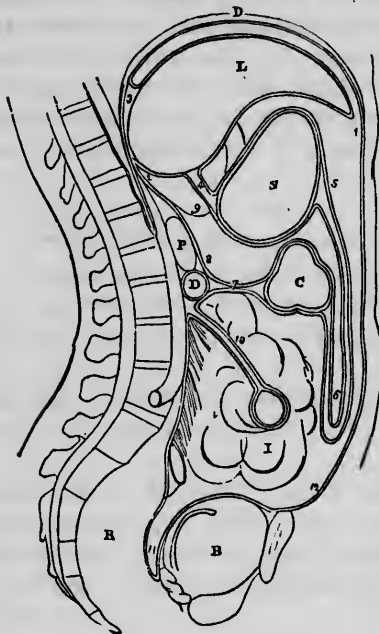


Fig. 49.—Represents a section of the middle portion of the abdomen. The organs are somewhat displaced and disproportioned, the chief object being to exhibit the peritoneal coat. Commencing at 1, it can be traced up under, and lining, D, the diaphragm, from which it is "reflected" at 3, to the liver L, over the front edge of which it can be followed, and under the liver to 4, where it turns on to the stomach, and at 5 passes down in front of the abdominal organs to a greater or less distance, when it turns upward, forming a kind of apron, commonly called the caul, a beautiful thin membrane in appearance, netted over with fat, being the part butchers put upon the front quarters of veal to give them a better appearance, as the fat caul from a good animal can be made to improve the appearance of an indifferent one. It can be traced to the colon C, one part of which it covers, and then leaves it to go to the backbone, touching upon and partly covering the duodenum D, when again it comes away for some distance to form the outer coat of the small intestine; the general outline of its convolutions being shown by L. The peritoneal coat can then be followed back to the spinal column, the two layers adhering at 10, forming the ribbon-

like part called the mesentery, between the two thicknesses of which the blood-vessels, the nerves, the lacteals, and the glands of the intestine are found. After continuing in a similar manner about the entire length of the second stomach, it follows down to 11, turns over the vesicle B, and passes up from 12 to 1, lining the walls of the abdomen, being there commonly called the film. The peritoneal coat, or peritoneum, adheres or grows to, or rather is a part of, those organs upon which it is found; the surface opposite to that which adheres, being "free," viz., not adherent to any thing, but continually moistened with a very glairy fluid. In general appearance, the peritoneum is a light pearl-colored, dense, strong membrane, rather easily torn off from the parts to which it belongs. If attention be again bestowed upon the figure, what appears another membrane, will be seen at 2, which passing down covers one part of the stomach, adhering at 4 to the peritoneum previously traced, and also at 5, from which it follows down, forming part of the caul, the two layers adhering to each other. It can then be traced up to the transverse colon; the surfaces between which 6 is placed not adhering, are moistened by serous fluid. It forms the outer coat of the upper part of the colon; adhering to its companion between the colon and D, the upper part of which it covers when passing over the pancreas, it is found at 2 again. Thus all the organs of the abdomen may move upon each other without the slightest degree of friction. The reader must not suppose that there are any spaces between the organs. They are in close contact, unless separated unnaturally.

Three kinds of free surfaces—Oil, Mucous and Serous Membranes.

203. *All "free" surfaces* must be composed of secretory tissue. Upon reflection, it will be noticed that there are three kinds of free surfaces. 1st. That which is external. 2d. That which is internal, but liable to the action of the air, or food, or irritating, harshly acting substances. 3d. Internal, but moistened only by unirritating fluids. The first surface must be protected by an oily fluid. Hence the skin is called oil membrane. The second must be kept in good condition by a viscid substance of a watery character. It is called mucous, and the lining where it is formed is called mucous membrane. The third is moistened by the serum, or some bland fluid, and hence the membrane is called serous membrane.

204. *Beneath the secretory tissue* the dense network of fibres are found. See Fig. 43. The fibrous is therefore as extensive as the secretory.

205. Some muscular tissue is required in the entire length of the digestive canal; in the air-passages of the lungs; to compose the respiratory muscles, and to form the chief part of the heart, while a little will be required in some of the vessels.

206. *Cartilage* is required only in the air-passages.

207. *All parts require nerves.*

208. The tissues of organic life must be kept in good condition; therefore in respect to their own tissues, the apparatus of organic life will be required to perform the same functions as in respect to the tissues of animal life.

209. Every part of the body is therefore composed of

Of what are all free surfaces composed? How many kinds of free surfaces? How are they distinguished? How are they kept in a good condition? What is found beneath the secretory tissue? Why is muscular tissue required?

 The relations of the two grand classes of Apparatus.

two classes of parts; one by which it may be said to be formed, and one by which it is preserved in a good condition.

Illus.—The skin is composed of a cellular layer, basement, and fibrous membrane, and of nerves, that it may be an organ of sense. It is supplied with blood-vessels, lymphatics, and oil and perspiratory glands, that it may be kept in a good condition.

 CHAPTER IX.

Apparatus of Relation and Organic Life compose the Physical Man—Their influence upon each other and the Mind—Tableau—Review of Part I.

210. *The physical man* is composed of two grand classes of apparatus, that of relation and that of organic life; and it must be kept in mind, that in functions they are entirely distinct from each other.

They always act in reference to each other, and are constructed for harmonious action; each may, however, in imagination, be entirely isolated, as the digestive organs of the fowl are, in Fig. 50, or as all those of the trunk in Fig. 51, which appear in their place.

Indeed, we might go so far as to imagine the digestive organs left out of the body, and in some place, to prepare food against our return. The apparatus used for cooking may, in one sense, be called a part of the digestive apparatus, which is so left, or which the emigrant frequently carries with him. Such a portion of the digestive apparatus as is absolutely necessary under all circumstances, and no inconvenience in any case, being made a part of the body, as it is usually regarded.

It has been already said that certain animals have no digestive apparatus. It is true, they have none connected with their bodies, but their food is prepared for their use, and whatever prepares the food, may be called the digestive apparatus of the animal, which it has no trouble about.

Of what is the skin composed? Do the classes serve the same purposes? What might be imagined in respect to the organic apparatus? Would an apparatus of organic life alone, have any purpose or be of any use?

Apparatus of Organic Life isolated.

Fig. 50.

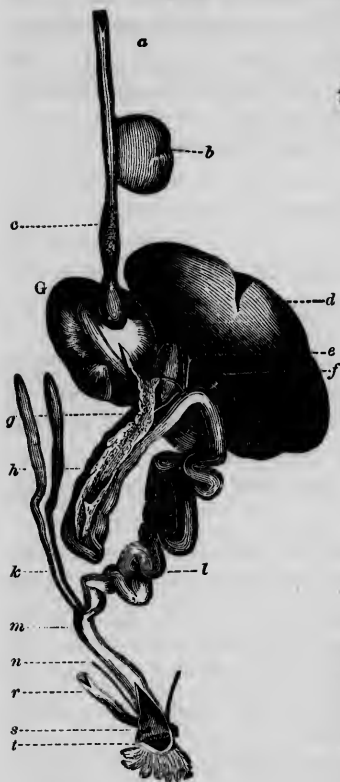


Fig. 51.

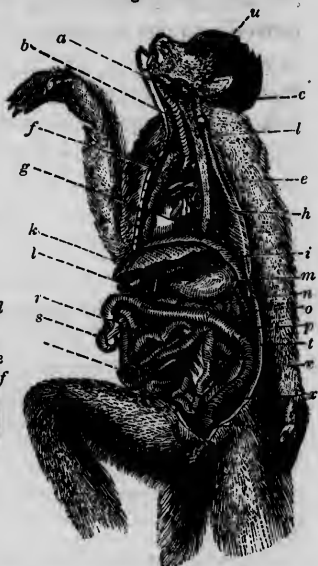


Fig. 51.—*a*. Maxillary gland.
u. Parotid gland. *b*. Trachea.
c. Pharynx. *l*. Esophagus. *f*.
 Lung. *g*. Heart. *e*. Thorax. *h*.
 Aorta. *i*. Diaphragm. *k*. Liver.
l. Gall-cyst. *m*. Stomach. *n*. Pan-
 creas. *o*. Spleen. *p*. Kidney.
s. Cæcum. *r*, *t*. Colon. *y*. Sec-
 ond Stomach. *v*. Abdomen. *x*.
 Rectum.

Fig. 50.—*a*. Esophagus. *b*. Crop. *c*. Ventricle. *G*. Gizzard.
d. Liver. *e*. Gall-bladder. *f*. Biliary ducts. *g*. Pancreas. *h*, *l*. Sec-
 ond Stomach. *k*. Cæca. *m*. Colon. *n*. Renal duct. *r*. Oviduct.
s, *t*. Cloaca.

In the same manner the circulatory and respiratory apparatus might be isolated, or they could be interwoven, as they are, with the exception of the vessels, in the body, for the purpose of being packed closely, and then the whole could be isolated as in Fig. 51.

Mutual Influences of the Mind and Apparatus of Organic Life.

211. *The apparatus of organic life* has no power of self-control, nor can it supply its necessities except in respect to oxygen, and very slightly in respect to water. It must, therefore, have some means of acting upon the apparatus of relation, and through it upon the mind.

212. On the other hand, the influence which the mind should exert upon the organic apparatus, except when it requires to use the breathing apparatus in speaking, should not be very direct. Indirectly, the influence of the mind should be very great; for, as the action of the mind is, so will be the labor which the organic apparatus ought to perform.

213. Nothing is more certain than that the health and good condition of the organic apparatus will tend to keep the apparatus of relation in good condition, and enable the mind to use it effectually, and, on the other hand, that the healthy, vigorous action of the mind, and a good disposition tend to exalt and preserve the health of the organic apparatus.

214. To possess and preserve the health and vigor of all parts of the body, therefore, we must first regard the original constitution as of importance. 2d. We must educate and cultivate the mind intellectually and emotionally. 3d. Exercise all parts of the body properly. 4th. As whatever the organic apparatus accomplishes is done by the circulation of the blood, whatever will facilitate it must be regarded of great importance. *a.* The system should be rubbed often and thoroughly. *b.* The clothing should be loose and comfortable. 5th. The character of the air must be observed. 6th. The character of food and its preparation.

Can the apparatus of organic life supply its own necessities? Why must it act on the mind? Should mental influence upon the apparatus of organic life be direct? What effect have the mind and apparatus of organic life upon each other?

 Golden Rules of Health—Structure of Body simple.

7th. The utility of water must be noticed. 8th. Cleanliness of the skin must be esteemed of primary importance. 9th. Clothing must be proper. The following tableau will exhibit synoptically what must be daily noticed.

TO PRESERVE AND PROMOTE HEALTH WE MUST DAILY GIVE ATTENTION TO

{ CULTIVATING THE INTELLECT AND DISPOSITION,
EXERCISING ALL PARTS OF THE BODY PROPERLY,
RUBBING THE SYSTEM THOROUGHLY,
WEARING LOOSE DRESSES,
THE CHARACTER OF WATER,
THE CHARACTER OF AIR,
THE CHARACTER OF FOOD,
PERSONAL CLEANLINESS,
WEARING PROTECTIVE CLOTHING.

215. Upon reviewing Part I. it will be seen that the structure of the whole body is much more simple than it is usually thought to be. Its complication arises from the different parts being interwoven with each other. There are, in reality, but a few kinds of parts, but there is an infinite number of divisions of them. They are all constructed upon the same principle, and all designed to accomplish a purpose which it is easy to understand should be accomplished. They are interwoven that they may be packed in a smaller space than they would otherwise occupy. Every place is usefully occupied.

216. Upon reviewing Part First, we see that the ends people wish to gain can be easily reached in the right way. Does the young lady wish to be beautiful? Let her cultivate an amiable disposition, and her complexion will become more clear and her features more attractive. Does a person wish to enjoy life, let him simply be willing to let others enjoy themselves as well.

To what must persons give *daily* attention in order to promote health, long life, beauty, strength, and happiness? Why does the body seem to be very complicated? Why are the parts of the body interwoven?

PART II.

GENERAL ANATOMY, PHYSIOLOGY, AND HYGIENE.

"It is said of Lord Bacon, that having collected a great number of books on gardening and rural affairs, and found them destitute of the information he sought, he caused them all to be piled up in his court-yard, uttering these memorable words: 'In all these works I find no *principles*; they can be of no use to any man.' To shield this humble work from condemnation on such grounds, has been the author's special aim."—DR. ALONZO POTTER.

General Remarks.

If any person takes a general view of the human body he will notice that it seems to be composed of many very dissimilar parts, designed for dissimilar modes of action and accomplishing different objects. But a more particular examination will convince him that similar substances are found in these differently appearing parts—the dissimilarity of these depending upon the number and proportion of the substances composing them. In the same manner as all the variety of musical pieces are produced from a few simple notes, so are the varied harmonies of this grand harmonic, the human body, produced by the combination of a few tissues possessing necessary properties. The close observer will perceive that the objects to be gained by the conspicuous parts first observed, require a combination of dissimilar properties.

Illus.—To act upon food as it ought, the stomach must be composed of a substance which can secrete gastric juice from the blood, of substance which can move its contents, of fibres which shall give it strength; viz., of secretory, muscular, fibrous tissues, &c. The heart requires muscular substance to throw out its contents, fibrous tissue to give it strength, &c.

If a person take a general view of the body, what will he notice? Of what will a particular examination of the body convince a person? In what respect does the human body resemble a piece of music?

It is not only proper but exceedingly important to distinguish between parts, groups of parts, and classes of groups designed for certain uses, functions and purposes, and those substances which compose them and possess certain properties which alone would be of no more use than a single note in music, but which combined with others most simply produce the most beautiful results. To have this distinction and those things which depend upon it clearly in mind, is to have a key which opens the whole human body to the mind's eye, gives to the understanding a clear idea of the modes of operation of this wonderful machine, reduces confusion to order, and brings the whole of Anatomy, Physiology, and Hygiene into the logical order of the strictest science, rendering them easy to understand, and explaining their principles in accordance with common sense views of things.

217. General Anatomy, Physiology, and Hygiene treat upon those parts of the body which compose the organs, upon their properties, and upon the modes of producing and preserving their best condition for desired use.

218. The first division of an organ which is usually made, reduces it to parts called tissues. As these are composed of parts also called tissues, they are distinguished as compound tissues.

Sometimes the parts of an organ may be separated, but not so as to obtain at once all the tissues, as the stomach might be separated into secretory, muscular, nervous and fibrous tissues, and blood-vessels, and lymphatics—the last two not being reduced to their constituting tissues. But it will be found, as it has been, that these vessels do not, properly speaking, *form* the stomach, but are added to it to keep it in a good condition. As the blood-vessels and lymphatics have uses, and not properly speaking properties, except such as are dependent upon their components, they should not be ranked as tissues—but are composed of compound tissues.

219. The whole of any tissue in the body is called a system—e. g., muscular system. A part of such a system is also called

What classification of the organs is it important to distinguish? What is a key to all the operations taking place in the human body? Upon what do General Anatomy, Physiology, and Hygiene treat? Into what is an organ first reducible?

Systems—Human Elements.

a system—e. g., the striated muscular system, sympathetic nervous system.

An assemblage of organs is never properly called a system, but an apparatus. "System of blood-vessels," is not a proper expression; neither are "lymphatic," "respiratory," or "digestive" "systems," proper expressions. Organs are of course composed of parts of different systems.

220. *Various fluids called Humors* are also found in the body and are subservient to the wants of its parts. From some of them the tissues are produced, and some of them are produced by the tissues.

221. The tissues and humors are composed of different proportions of substances common to several. These substances may therefore be called the elements of the tissues. But as they are themselves compounds and never found beyond the domain of life, they are most appropriately called anatomical elements.

They are also called organic and proximate elements.

222. The anatomical elements are composed of still more simple elements which are called chemical, and inorganic, elements.

223. As the chemical and organic elements are obtained from food, water, and air, these should be discussed; also the influence of heat, light, and electricity.

224.

GENERAL HUMAN ANATOMY,
PHYSIOLOGY, AND HYGIENE
Treats upon

{ SYSTEMS,
TISSUES,
HUMORS,
A. ELEMENTS,
C. ELEMENTS,
FOOD, WATER, AND AIR,
HEAT, LIGHT, AND ELECTRICITY.

Is an assemblage of organs a system? Of what systems are organs composed?
What are humors? What are elements?

CHAPTER I.

Chemical Elements, Simple and Compound.

225. *Simple chemical elements*, are the names given to the smallest atoms of matter.

They are so exceedingly minute that the keenest eye, assisted by the wonderful powers of the most highly magnifying microscope, fails to distinguish them; it can only see collections of atoms.

226. Thirteen different simple elements are essential to the composition of the human body.

Fifteen or sixteen are usually found; sometimes nineteen.

227. The names of the thirteen essential elements are: Oxygen, Hydrogen, Carbon, Nitrogen, Phosphorus, Sulphur, Calcium, Magnesium, Iron, Potassium, Sodium, Chlorine, Manganese; frequently Silicon and Aluminium are found; and sometimes Fluorine and Copper.

Of the simple elements very little need be said in this work, as in a simple form they do not exist in the human body; and a perfect knowledge of the properties they exhibit alone, would not enable a person to predicate how they would appear or the effect they would produce when compounded.

Illus.—Oxygen and hydrogen are gases when simple; but when compounded, they form water.

228. Under proper circumstances, the simple elements exhibit strong tendencies to unite with each other. In the act of uniting some of them become very serviceable; while some form very valuable compounds, the properties of which are very dissimilar from those of either simple, alone.

Illus.—When oxygen and carbon unite, caloric is produced or exhibited by the very act.

What are simple chemical elements? How many elements in the human body? Of what is water formed? What is the effect and result of uniting simple elements? What is the effect of uniting carbon and oxygen?

Compound Chemical Elements.

229. *Compound chemical elements* are the names given to all those compounds which are found in the inorganic world.

Illus.—Phosphorus united with oxygen in proper proportions forms a compound called phosphoric acid.

230. *Sometimes* two compound elements unite with another, or with two or more others which have previously united, and thus a double compound is formed.

Illus.—Phosphoric acid unites with lime (a compound of oxygen and calcium) and produces phosphate of lime, a conspicuous ingredient of the bones.

231. The properties of many of the compound chemical elements are exhibited by many parts of the body in which they are found.

Illus.—Water exhibits its most conspicuous properties in various tissues and humors, and its presence in them is at once detected.

232. Under proper circumstances, the components of the chemical compounds will separate from each other, which is called the act of decomposition, and in the act of decomposing sometimes exhibit very valuable properties. In this case they rarely, if ever, remain simple for any noticeable length of time, but at once unite with some other elements or compounds. Thus a double compound becomes more simple, but never resolved into its simple components. Decomposition is, therefore, always to be associated with composition, usually, however, of simpler compounds, though sometimes of more complex.

233. The chemical compounds of most frequent occurrence or utility in the human body are, 1st. That of oxygen

What are called compound chemical elements? Phosphorus and oxygen form what? Phosphoric acid and lime form what? Are the properties of any of the compound chemicals exhibited in the body? What is decomposition, and what is its effect?

Chemical Compounds of most frequent occurrence.

and hydrogen—water. This composes more than one-half the weight of the entire body—nearly four-fifths. When oxygen and hydrogen unite to form water, caloric is given out. When the compound is formed by any chemical experiment, such a quantity is produced that the heat becomes intense and burning. If minute quantities of water are compounded, the amount of caloric is small, and could be borne without inconvenience by the most delicate tissues. When water changes into vapor, whether at high or low temperatures, it takes up caloric, thereby cooling every thing about it.

234. 2d. Oxygen uniting with carbon exhibits caloric, and produces carbonic acid. The existence of this in the body we do not recognize, except in the blood. It is chiefly exhibited as it is passing from the lungs. It is a gas, imperceptible to any of the senses; but if the breath is passed through lime-water, the presence of carbonic acid is at once manifested. It is a poison of a most deadly character, if inhaled or left in the blood in any considerable quantities; ten per cent. in the air breathed is sufficient to cause death. Instead of being manifest through any one of the senses by producing any discomfort, it is rather quieting, causing a person to feel heavy, and inclining him to sleep. It is not, however, "balmy sleep," the "sweet restorer," but a treacherous death, as certain as it is subtle. It is, in smaller quantities, a poison which brings on headaches and many bad feelings.

Inf.—Persons should be exceedingly careful not to expose themselves in places where this deadly carbonic acid is produced. Coal

What proportion of the weight of the body is water? What is the effect of forming in the body minute quantities of water? What is the effect of vaporizing water? What is the effect of carbonic acid?

Nitrogen—Phosphorus—Sulphur—Calcium.

stoves which do not draw well, or have their damper turned to quench the fire, pour out the unhealthy carbonic oxide which should pass off by the flues; and because there is no smoke, and the eyes do not smart, the evil is not recognized. A flue that will not "draw" smoke will not "draw" carbonic gas. Every person's mouth is a flue opening from his lungs, which pour out the poisonous carbonic acid, warmed so that it will ascend and pass away, except as it is obstructed by the walls of tight rooms. Ventilation is all-important.

235. Oxygen does not combine with nitrogen directly in the body. It is mixed with nitrogen, in the proportions of one to four, and thus forms the atmosphere, or very much the greater part of it.

236. Oxygen combines with phosphorus to form phosphoric acid, which is found in various parts of the body, but does not in them exhibit any of its peculiar characteristics.

237. How sulphur exists in the body is not determined. Some think it combines with oxygen, forming sulphuric acid, which unites with other elements; but this is not probable. Sulphur exists in direct union with the elements where it is found.

238. Oxygen unites with calcium to produce lime, and with magnesium to form magnesia, the characteristics of which are, to a certain degree, easily recognized in the harder tissues of the body.

239. In what form, of a chemical character, iron exists in the body, has not yet, strange to say, been well determined. It probably occurs, in combination with oxygen, producing oxide of iron (iron rust), and with carbonic acid, producing a carbonate of the oxide.

240. Potassium and sodium seem always to be united

What will result if a coal stove has not a good "draught?" Why is ventilation all-important? In what state does oxygen exist in the air? In what form does phosphorus exist in the body? What are the products of calcium and oxygen?

Tableau of Chemical Compounds—Organic Elements.

with oxygen, forming potash and soda. The characteristics of these are not conspicuously exhibited by any part of the body except upon chemical analysis. Sodium unites with chlorine, producing common salt, the taste of which can often be recognized in the tissues and humors.

241. Oxygen unites with magnesium, producing a compound which adds its firmness to the tissues it composes.

242. The following tableau is synoptical:—

The most important and easily recognizable compound chemical elements in the body are,	{	WATER,
		CARBONIC ACID,
		PHOSPHORIC ACID,
		LIME,
		MAGNESIA,
		OXIDE AND CARBONATE OF IRON, CHLORIDE OF SODIUM (SALT).

“The physiologist has much less to do with the ultimate components (chemical elements) of the animal body, than he has with the organic compounds (organic or anatomical elements) supplied to it as nutriment and composing its fabric.” It will not, therefore, be requisite to dwell longer on this part of our subject. We will pass to consider the nature and properties of these compounds, and the changes they undergo.

CHAPTER II.

Anatomical, Organic, or Proximate Elements, simple and compound.

243. ORGANIC ELEMENTS are the names given to the simplest substances formed by organic bodies.

They are compounds, but are never found beyond the domain of life. They are also called proximate principles.

244. *Organic elements are distinguished* from chemical

How are potash and soda composed? Of what common salt? What are the most easily recognizable chemical compounds in the body? What has the physiologist to do with the chemical elements? What are organic elements?

Composition of Organic Elements.

compounds by, 1st. Being usually composed of a greater number of simple elements.

Illus.—Water is composed of two—carbonic acid of two; while the simplest of organic elements is composed of three, and all kinds of animal organic elements, except fat, of at least four or five.

245. 2d. *Each atom of the organic element* is composed not only of more kinds of simple elements, but of a greater number of atoms of each kind.

Illus.—One atom of water is composed of one atom of hydrogen and of one atom of oxygen; while one atom of cane sugar is composed of 12 atoms of carbon, 11 of hydrogen, and 11 of oxygen.

246. 3d. When chemical compounds are formed of more than one or two elements, usually, two first unite forming one, which unites with a third, or another similar binary compound; but in the organic compound each element seems to unite equally with all the rest.

<i>Illus.</i> —1 Carbon	} unite to form carbonic acid. }	} Unite to form carbonate of ammonia.
2 Oxygen		
1 Nitrogen		
2 Hydrogen		
	} unite to form ammonia.	

If carbonate of ammonia had been an organic compound, it would have been found as the following representation indicates:

1 Carbon	} Carbonate of Ammonia.
2 Oxygen	
1 Nitrogen	
2 Hydrogen	

But the atomical figures would also have been much greater.

It follows, that when a chemical compound decomposes it may merely separate into simpler compounds or simple elements; but when an organic compound decomposes, necessarily a new composition of its composing atoms will take place, and new compounds will form—the character of which will depend upon many circumstances.

How are organic distinguished from chemical compounds? Of what is an atom of sugar composed? What would be the difference between carbonate of ammonia as an organic and as a chemical element?

Organic Elements distinguished.

247. 4th. A greater number of kinds of organic than of chemical compounds can be formed from a few elements.

This is evident, as the range of numbers of combining atoms is so great in organic bodies.

248. 5th. Organic elements are very unstable, 1st. Because they are composed of so many elements that the attraction between them is not so clear as where but two are united; 2d. Because of the proportion of nitrogen which is found in the animal compounds; 3d. Because of the quantity of water composing them in the natural state.

Illus.—Water, composed of but two atoms, is very permanent; while peroxide of hydrogen, composed of two atoms of oxygen to one of hydrogen, is very easily decomposed. Sugar and fat—organic compounds which do not contain nitrogen—are quite permanent compared with lean meat. Lean meat, when dried, or when its water has been removed by the action of salt or alcohol, will “keep” a long while. Nitrogen is mixed, yet does not combine with oxygen in the air, though both are in a gaseous state, which shows that the attractions of nitrogen are weak.

249. The elements of organic compounds have no such simple arithmetical relations of their anatomical numbers as is observed in chemical compounds.

What has been said will not apply to all the elements which enter into the tissues of the body, but is generally correct.

250. Simple organic elements are those which are not compounded of any organic compounds, while compound elements are.

Simple organic elements may be compounded of chemical compounds. Some of those which are now thought to be simple may be found to be compound.

Why can more organic than chemical elements be formed from a few simples? Why are organic elements unstable? What illustrations show that water assists decomposition? What difference between simple and compound organic elements?

Formative Elements.

251. Another great and important division of the organic elements is into, 1st. Those from which the body can be formed; 2d. Those which are produced by decomposition. The first are called formative elements; the second excrementitious or secondary.

The last embraces a great number of compounds, their peculiar composition, and properties, varying very much in different cases. In this work a description of a very few only will be useful or interesting.

252. *The formative organic elements are divisible* into those which do, and those which do not, contain nitrogen.

253. *Those containing nitrogen are called* Albumen, Fibrin, Casein, Gelatin, Chondrin, Globulin, Hæmatosin.

254. *Those which do not contain nitrogen are* Fat, Starch, Sugar, Honey, Gum, Cellulose and Lactic Acid.

255. *Fat is composed* of three simpler organic elements, called Oleine (pure oil), Margarine (spermaceti), and Stearine (stearine, adamantine, or lard candles are composed of it).

256. *Each of the three* are composed of still more simple organic elements, viz., Oleic, Margaric, and Stearic acids, combined with a base called Glycerine—a thick, sweetish fluid.

These last compounds do not exhibit their peculiar qualities in the body.

257. *All these* components of fat are composed of oxygen, hydrogen, and carbon.

258. *Human fat is composed* of oleine and margarine; congeals at about 40° Fahr.: is therefore fluid during life, and appears like a clear amber-colored oil.

Inf.—If any artificial “hair-oil” is used, it should be as nearly

What are formative elements? What are secondary elements? Into what classes may the formative elements be divided? What are the names of the nitrogenized? Of the non-nitrogenized? Give the composition of fat. Of human fat.

 Nature of Fat, and where found.

as possible composed of oleine. Beef's marrow, lard, bear's grease, &c., contain too much stearine. Animal fats may be compressed at a low temperature, and the oleine obtained; but it becomes rancid quicker, usually, than the oleine of vegetable oils. The pure oil of sweet almonds, olives, and castor-beans is the best toilet article. Expose it to a low temperature, and pour off or express the liquid oleine.*

259. *Fat exists* in the blood, milk, and chyle, in the form of small globules, the outer surface seeming to be a thin pellicle of albumen.† It may also exist in the blood in a dissolved state. It enters into combination with some of the compounds of sodium, and also, it is supposed, unites with phosphorus or its compounds. It is a constituent of the brain, but how combined in it is not yet determined. Its peculiar characteristics are not there exhibited. Fat is chiefly found deposited in minute cells. Sometimes these are single, but usually numerous, scattered throughout the body, and accumulated in masses or layers. In some parts, however, fat is never found—e. g., the eye-lids. The parts where it accumulates vary in different persons and at different periods in life.

Illus.—In children it forms a thick layer beneath the skin: in old persons it forms masses about the internal organs.

The cells and their contained fat form what is called adipose tissue. Fat is not, however, a tissue, and the cells which contain it belong to the secretory or cellular tissues. Adipose tissue is not therefore a proper expression: fat is merely an organic element, and would be more properly classed among the humors than tissues.

* If its cheapness is an objection, call it by some high-sounding name, and pay more for it.

† In the process of churning, this pellicle is disturbed, and the fat collecting "forms the butter."

What is the best hair-oil, and why? In what fluids does fat exist? Where, in the body, is fat chiefly formed? What is butter? What is adipose tissue? Why might fat be classed among the humors?

Properties of Fat—Starch.

260. *Fat has two properties* of great use in the body. It is a non-conductor of heat, and deadens jars acting through it.

Illus. (a.)—The whale—a warm-blooded animal, which has its home among the icebergs of the Arctic Ocean, is provided with a thick layer of fat beneath its skin to prevent the escape of heat. The swine, having little or no protection in his bristles, adds to himself, especially in fall and winter, a stratum of fat.

Inf.—Every person should become thinner as spring and summer advances, nor fear consumption or other diseases because they do not weigh as much as in winter.

Illus. (b.)—Fat in the form of marrow exists in the bones to deaden the jars of walking, &c. It also serves as a cushion for the eye at the bottom of the socket.

261. Fat will also, by decomposition, produce heat. It is in this way that it is chiefly useful in the body.

Inf.—In spring and summer any person's appetite, especially for fat, and those kinds of food which will produce it, ought to diminish; nor should he feel alarmed at this, or stimulate an appetite by bitters or other medicines.

262. *Starch exists in the form* of small kernels, the substance of which is arranged in concentric layers like those of an onion.

It is therefore a compound element, though it is chiefly composed of similar particles. To expose all these, the kernel must be cracked open. This is readily done by heat of 165° , which, especially if applied slowly, changes a part of the starch into dextrine, a sweetish, easily digested, and very wholesome substance.

Inf.—All kinds of food containing starch, should be cooked for the use of man or animals.*

* The mode of cooking starch is not unimportant. The excellent constitutions of

What two important properties has fat? In what animals is heat preserved chiefly by fat? When should most persons be "fat?" Why is fat found in bones? How can fat produce caloric? What is the form of starch?

Saccharine Substances—Cellulose.

263. *Starch is not a compound* of the animal, but is produced by vegetables, being stored up in the seeds, roots, and stems of many of them. It is, however, a very useful article of food to animals; it is composed of oxygen, hydrogen, and carbon, and can therefore by addition to, or subtraction from, some of its elements, be changed into dextrine, glucose, sugar, gum, or into fat; all of which are composed of similar chemical elements.

264. *Sugar, honey, gum, dextrine,* and the like sweetish substances, are called saccharine compounds, and are composed of oxygen, hydrogen, and carbon, and may of course be changed into each other. They are products of the vegetable world, and are also produced from each other by the vegetative or chemical processes going on in animals.

265. *Sugar exhibits several varieties.* It is found in the milk (milk sugar) and in the blood (glucose), especially of the liver (hepatic sugar). As sugar, it does not compose any of the tissues. Its use in the body is calorific or to form fat.

266. *Cellulose* constitutes a considerable portion of the cellular parts of plants. It is very similar to starch, and, like the lignine or woody portion, can be prepared for the use of animals in producing caloric or fat.

the Scotch are not a little attributable to their use of oatmeal, kiln-dried or parched. The Indians make excellent use of parched corn, in long, cold marches and hunts; it is the very best mode of using Indian corn. Pigs will soon show, by their increased weight, that "it pays" its preparation for them. Ground or pounded, and used in water or milk, or made into puddings, it is excellent. The "corn balls" of the confectioner are very useful as food in cold weather; three or four of them will make a very complete dinner. The introduction and preparation of parched corn, oats and wheat, for food, is very desirable for the health and pecuniary profit of people.

Why should starch be cooked? What is said of oatmeal and parched corn? What produces starch? Into what may starch be readily changed? What is the use of sugar in the body? What is cellulose?

Lactic Acid—Albumen—Fibrin.

267. *Lactic Acid* is a compound of oxygen, hydrogen, and carbon, and very easily produced from the substances last mentioned. It is, however, by many described as an excrementitious substance, and can doubtless be formed from some of the decomposing parts of the body. It is a thick fluid when highly concentrated, of a dark color and acid taste. It is found in the gastric juice—in the juice of the flesh—and it is supposed to always exist in minute quantity in the blood. It is easily decomposed, and then produces heat.

Nitrogenized Compounds.

268. *Albumen* is the chief ingredient of eggs; it is chiefly composed of oxygen, hydrogen, carbon, nitrogen, sulphur and phosphorus; it is hardened by the action of caloric, alcohol, and some acids. In the blood, chyle and lymph, it is dissolved, and appears as a fluid; in the tissues, of which it forms a part, it is a solid or semi-solid; its solidity is not produced by a hardening similar to that caused by caloric; it is produced by vegetables, and derived from them either directly or indirectly by animals.

269. *Albumen* has not any remarkable, peculiar properties, which it exhibits in the tissues or humors formed from it; it exists in the blood, chyle, lymph, milk, serous and mucous fluids; it forms, to a great degree at least, the secretory, nervous, and fibrous tissues.

270. *Fibrin* is very similar in composition to albumen, from which some suppose it is formed; it is the chief element of the muscular or fleshy tissue. When the blood is expressed from it, it has a yellowish white appearance, and

What is lactic acid? Where is it found in the body? What is the appearance of albumen? Of what is albumen composed? How does it exist in the blood? What is its consistence in the tissues? What parts of the body does it form? Describe fibrin.

is of a soft, tenacious consistence; its most remarkable property is that of coagulating when exposed to the air, as is seen by the clotting or coagulating of drawn blood. The clot is fibrin. This valuable property of coagulating, it frequently manifests when stagnated in the body; it is found in the muscles and blood.

Some suppose that fibrin is formed from albumen, and therefore that the muscles are so formed. Such persons think the fibrin of the blood is produced by the decomposing muscles. That fibrin may be formed from albumen, is evident in case of the muscles of the chick, which are formed from the albumen of the egg; but fibrin, or, at least, what is so called, is also found in the plant. This is, however, very likely a different substance from the fibrin of animals; for, as vegetables have no muscles, of what use would fibrin be to them, or how could it be produced? It is a question whether fibrin can be produced except by the sarco-lemma or other parts of muscular tissue.

271. *Casein* is another element similar to albumen, except that it is wanting in phosphorus; it is the chief part of milk curds, and is of course found in milk. When used as food, it undergoes changes before passing into the blood-vessels, where, in the form of casein, it has never yet been detected.

272. *Globuline* is a compound very much resembling caseine; it differs from both it and albumen in some respects; it is found in the red corpuscles of the blood.

273. *Hæmatin* is a compound of oxygen, hydrogen, nitrogen, carbon and iron, as its chief chemical elements; it is found in the red corpuscles of the blood.

Neither Hæmatin nor Globuline have yet been so perfectly isolated in considerable amount that an exact chemical analysis of them could be made.

What is a remarkable property of fibrin? Can fibrin be formed from albumen? By what part is fibrin probably secreted? What is caseine, and where found? What is globuline, and where found? What is hæmatin, and where found?

Gelatin—its Production—Protein.

274. *Gelatin*, as it exists in the body, is of two kinds; one is obtained from the fibrous tissues, and called gluten; the other, called chondrin, is obtained from cartilages—they are very similar to each other, either being called by the common name, glue. Gelatin has the property of uniting with tannin and forming leather; Gelatin does not exist in the blood, and therefore must be formed from some of its components; and, when decomposed, its elements must unite to form other compounds.

275. *Gelatin* is produced from albumen, but does not contain as much sulphur as albumen, nor does phosphorus seem to be a necessary element; it is obtained by boiling the fibrous tissues and cartilages; the last require to be boiled for a long time.

If gelatin be used as food, it cannot be of service as a nutritious substance, since it is not found in the blood, and because it does not contain the proper proportions of elements to form albumen. Its use, then, if taken as food, must be to produce caloric or fat, for which it is very valuable. After it has served its purpose in the part which has produced it, or for which it was produced, it may be of still farther use as a calorific.

276. *Protein* is a name given to a substance easily obtained from albumen, fibrin, and casein. Some suppose that these are formed from protein by the addition of proper elements, and they are therefore called protein compounds.

277. *With these elements containing nitrogen*, various salts and chemical elements or compounds combine in ways which are not yet understood, and some of them in quantities which yet defy detection or measurement.

Substances which cannot be satisfactorily analyzed, or their mode of combination made out, are called by Chemists extractives.

Describe gelatin. What is the difference between gelatin and chondrin? From what is gelatin produced? Why cannot gelatin be nutritious? What, when eaten, must be its use in the body? What is protein? What are extractives?

Excrementitious or Secondary Organic Elements.

The number of them is constantly diminishing as Chemistry is perfected.

278. *Excrementitious, or secondary organic elements*, may be divided into classes, but it is necessary to mention only a few of them. Urea is a crystalline substance, causing a cool, saltish taste; it is composed of 2 oxygen, 4 hydrogen, 2 carbon, 2 nitrogen, which, by the addition of 2 atoms of water, can be formed into 2 carbonic acid and 2 ammonia. In the form of urea it is supposed that most of the nitrogen of the decomposed tissues, finds its way from the system. Creatine is a colorless, transparent, crystalline substance, of a bitter, pungent taste, composed of 4 O., 9 H., 8 C., 3 N. It is very sparingly found in the blood, exists in the juice of flesh and the eliminations of the kidneys. From this another substance called creatinine is formed. Nitrogen is a constituent of both, and removed from the body with them by the action of the kidneys. Glycocholic acid is a substance removed by the liver; it is composed of cholic acid, 9 O., 39 H., 48 C., and glycine 4 O., 5 H., 4 C., 1 N.—an exceedingly small quantity of oxygen, and scarcely any nitrogen. Another substance, called taurine, removed by the liver, contains a notable quantity of sulphur. The coloring matter of the bile is largely composed of hydrogen and carbon. Thus the biliary compounds have the same relation to carbon, hydrogen, and sulphur, as the renal compounds have to nitrogen and phosphorus.

Horny matters and mucus may also be considered as excrementitious; for, though they are useful to the body, they are also eliminated from it. Horny matters are mostly albuminous, with

What is urea? In what form does urea find its way from the system? What is creatine? What are the most conspicuous substances removed by the liver? What is the difference between substances removed by the liver, and those by the kidneys?

 Review of Elements—Division of Tissues into Simple and Compound.

an increased proportion of sulphur and some saline substances. Mucus is also albuminous.

In the secreted fluids of the body, there are many substances which are in very minute quantities, and the importance or use of which cannot as yet be determined; they had better be noticed when the parts where they are produced are described.

279. If we now review the organic elements, we shall see that they may be divided into four classes: 1st. Those which are calorific or fat-producing. 2d. Those which are adapted to nourish the tissues—formative. 3d. Those which absolutely form the living tissues. 4th. The excrementitious compounds.

 CHAPTER III.

Tissues and Humors, simple and compound.

280. *A simple tissue* is a cohesive, homogenous combination of several atoms of one or more organic elements. It is exhibited under four forms: 1st. As a mere aggregation of atoms, forming what is called a granule. 2d. Spread out like a sheet, and called a membrane. 3d. Formed into a hollow sphere or bubble, and called a cell. 4th. Extended like a thread, and called a fibre.

281. *Compound tissues* are formed from the simple ones—sometimes together with chemical elements—not so much by combination as by interweaving and overlaying.

Before, however, describing the tissues particularly, it will be best to speak of the properties which are common to all of them. They have, of course, physical properties in common with all bodies, viz., extension, density, &c.; but they are endowed with

Into what four classes may the organic elements be arranged? What is a simple tissue? What is a granule? What is a membrane? What is a cell? What is a fibre? How are compound tissues formed?

Common, essential properties of Tissues.

peculiar properties, called vital, that may well arrest our attention and excite our admiration.

282. *All the tissues* have three common, most remarkable, and essential properties, viz., of nutrition, development, and reproduction.

283. *By the property of nutrition* is meant the power of causing those changes in its own substance which are necessary to its preservation. This is a twofold process. 1st. The substance which has become worthless, is to be removed. 2d. The tissue must have the property of adding to or changing into itself the elements which are to replace the useless excretion.

Nutrition is the term usually applied to the 2d process mentioned. It, however, presupposes excretion.

284. *By development is meant*, not the process of substituting useful for useless substance, but the process of adding substance to that previously formed, and, if necessary, so changing it from the character of the previously formed tissue that any new, desirable characteristics may be exhibited.

285. *By reproduction is meant* the production of similar tissues, or what by development shall ultimately become similar, and independent of the producing tissue.

All these three properties belong to every tissue. This *must* be the case; for, if substance similar to a tissue could be formed at a distance, it could be added to the tissue only by the tissue itself. This is an idea which must be fully appreciated; for thus it appears that every tissue is to a certain degree independent; it is dependent in man upon other parts for preparing and bringing to it nourishable substance; but, if this is received, the tissue lives, acts, and dies within itself, and not only each tissue, but each integral part of a tissue.

286. *Nutrition must always* be going on in any living

What are the names of the three properties common to all the tissues? What is nutrition? To what process is the term nutrition usually applied? What is meant by development? What meant by reproduction of the tissues?

Nourishment of Tissues—Capillary Attraction.

tissue. Development and reproduction take place as the necessities of the case require, and can be suspended or intermitted without harm.

287. *A tissue is nourished* not merely at its surface, but throughout its substance

This renders it necessary to call attention to another fact, or operation. If substance is to pass to or from the midst of any mass, it must have the power of passing through or between the particles of the mass. If the movement is inward, it is called endosmose; if outward, it is called exosmose; but the movements are dependent on what is called capillary attraction. By this is meant that the surfaces of minute tubes have an attraction for their contents, which will therefore rise in the tubes, even against the effect of gravity. If the attraction between two substances—especially if one is a liquid and the other a solid—be great, some of one (the liquid) will adhere to the other, which is said to be “wet” or “wetted” by the adhering one. If an experiment is tried with several substances, it will be seen that some rise higher in the tubes than others, which will not so much “wet” the tubes as the first, which have a greater attraction for the substance of which the tubes are composed. Now, between the minute particles of most if not all substances, still more minute tubes may be supposed to exist, through which other substances can pass more or less freely or rapidly, according to the nature of the substances, especially the attraction between them. But again, where the attraction between substances is great, the particles of each will move among themselves in order to allow a mixture to take place. This is easily seen in case of fluids—e. g., in the simple case of water poured upon sugar or salt, it will be found after a short time that the particles of the solid substances have separated from each other and moved up between the particles of water till they are equally disseminated or dissolved through the whole; nor is this operation restricted to solids and liquids of the like character; mercury will pass into and amalgamate an entire mass of gold, one of the most solid of known substances. It is also to be noticed that water does not equally dissolve and suspend all substances—e. g., it will take up but very little, if any, starch. The force with which liquids and gases mix with each other, is called

Which processes are incessant in a living tissue? In what part is a tissue nourished? What are endosmose and exosmose? What relation have they to capillary attraction? What is the object of the illustration by mixing sugar and water?

The effect of Capillary Attraction—Nutrition.

the force of mixture; but it is only another name for the attraction of dissimilar substances for each other. If now an experiment be tried by filling a bladder or other membrane with a liquid—e. g., a strong solution of water and salt—and then immersing it in a bowl of clear water, it will soon be found that the clear water is passing into the bladder to mix with the solution. If the clear water be within and the solution be without, the contents of the bladder will soon be diminished.

But the passage is not simply in one direction, as this experiment might induce one to suppose. If water and milk be tried, or blood and milk, or alcohol and water, it will be found that the passage is taking place both ways at the same time, but more actively from the lighter toward the denser. Thus are apparently manifested two forces, called capillary attraction, and the force of mixture, but both are dependent on the same thing, the attraction of particles of matter for each other, which attraction is greater or less, according to the substances considered. The action of endosmose and exosmose* in the tissues of the body take place, therefore, upon physical principles, and are not peculiar to organized tissues; and, as it only requires longer to dissolve a portion of sugar through a gallon than through a gill of water, so would it only require longer to dissolve the nutriment through the entire body than through a minute part of it. It therefore follows that the more minutely any tissue is divided or intersected by blood-vessels, the more rapidly can the nourishment be dissolved or attracted through it.

238. *That a tissue may be nourished*, it is necessary,
 1st. That useless substance should be removed from, and useful substance brought to, the surface of the tissue. 2d. That both classes of substance pass freely through the tissue. 3d. That the tissue have the power of transforming the useful substance into itself.

From the statement just enunciated it is seen, that the greater the extent of surface presented by the tissue, the more active its

* By some of our best physiologists it has been advised to drop the use of the words endosmose and exosmose, and use capillary attraction instead.

What is called force of mixture? If water be placed in a bladder which is immersed in milk, what is the effect? Upon what are capillary attraction and force of mixture dependent?

Surface of Tissues increased—Excretion.

nourishment; and that the more active the tissue, the greater should be the extent of its surface, which is obtained by means of blood-vessels, as seen by fig. 52, which represents, very much magnified, a multitude of blood-vessels intersecting a tissue in every direction, a thousand times increasing its surface presented to nourishment above what would be, if it were a mass without blood-vessels, as some of the tissues are.

Fig. 52.

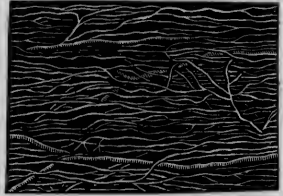
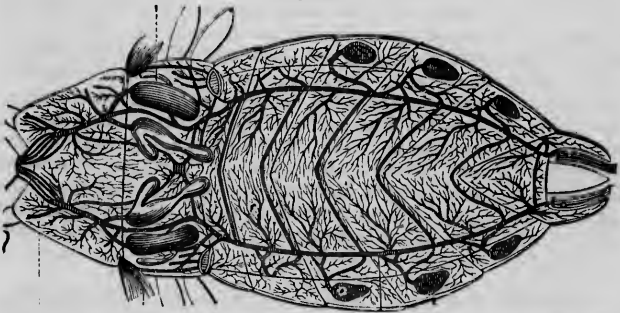


Fig. 53 represents the larger blood-vessels of an animal, through

Fig. 53.



which the nutriment can be carried to the capillaries, represented by fig. 52. The two show how the internal surface of the tissues is wonderfully increased; the whole inner surface of the blood-vessels, and of course of the tissues, of a man being millions of times greater than that of the skin.

289. *Excretion* is the name usually given to the act of casting from the tissue its useless substance. *Nutrition* is the name given to the act of renewal; it is also frequently applied to the process of growth and development. *Absorption* is the name given to the process by which the substance

How can the surface of tissues be increased? Describe fig. 52. Are all the tissues equally supplied with blood? Which have the greatest number? Describe fig. 53. To what is the term excretion usually applied? To what the term nutrition?

Absorption—Simple Tissues.

either passes into the tissue from the vessels, or from the tissue into the vessels, or through the external or mucous surface of the body into the vessels.

Absorption is a very indefinite term, but (perhaps on that very account) very convenient for use. Its literal meaning is, to drink up. It was brought into use when physiological knowledge was in its infancy, and was applied in any case where substance was taken into the body, or removed from any part of it. It is spoken of as if there were several different kinds; viz., there are, 1st. tissural or textural absorption; this refers to the passage of substance into the tissues. 2d. Capillary absorption; this refers to the passage of substance into the capillaries. It is called external absorption when substance from without the body passes into the vessels; and internal, when substance passes from the tissues or surfaces of the serous membranes into the vessels. 3d. Venous absorption refers to the passage of substance into the veins, though very little passes through veins, the term being adopted before the existence and mode of action of the capillaries were well understood. 4th. Lymphatic absorption refers to the passage of substance into the lymphatics. 5th. Lacteal absorption refers to the passage of substance into the lacteals. 6th. Recremental absorption refers to the absorption by something of recrementitious substance. 7th. Absorption of the tissues means, not absorption of something by them, but absorption of them by something. 8th. Absorption of poisons is an expression signifying, not that the poisons absorb, but are absorbed.

Absorption is also spoken of as selective or special, and general. By selective, is meant the absorption of particular substances only; by general, is meant the absorption of substances generally, those which are to be used and also those which will be useless.

By the term absorbents is or should be meant any thing—tissues, vessels, &c.—which absorbs; but the term is frequently applied to the lymphatics only, as they were formerly, or at one time, supposed to be the only, or at least the chief, parts of the body that absorbed.

Simple Tissues.

290. *A granule* is the simplest form of tissue in the

What is the literal meaning of absorption? When was it brought into use? How many kinds of absorption, and what are they? What is selective or special absorption? What should be meant by the term absorbents? What is a granule?

Simple Membrane—Secretion.

body. It is an aggregation of elements, the peculiar arrangement of which, if there be any, has not as yet been determined. They are smaller than a ten thousandth of an inch in diameter. When seen in a fluid they appear to be constantly vibrating, and sometimes dart about without apparent cause. It is supposed they are of a fatty and albuminous nature. They exist "*free*" in blood, lymph, chyle, milk, and some other fluids of the body, and are inclosed in many of the cells, and in the bones and teeth. The properties or uses of the granules are too little known to be spoken of here.

291. *A simple membrane* is, next to the granule, the simplest of tissues. It is a homogeneous expansion of matter, and seems to be composed of albuminous substance. It is exhibited in three forms: 1st. Spread out like a sheet, and then called *basement membrane*. 2d. Formed into a sphere, and then called *cellular membrane*. 3d. Tubulated, as in case of the minute vessels, and the sheath of muscular fibrillæ, where it is called *sarco-lemma*.

292. *In addition to the properties* of nutrition, development, and reproduction, which simple membrane possesses in common with other tissues, it has the important property of secretion.

293. *By secretion* is meant either separating or forming from the blood some substance which is dissimilar from the secreting tissue, and of course not needed by it.

It is similar to nutrition in this, that substance is separated or compounded from the blood; but it is dissimilar in this, that the substance formed or compounded is dissimilar to the secreting tis-

What is a granule? Where do they exist? What is a simple membrane? In what forms is it exhibited? What is the peculiar property of simple membrane? What is meant by secretion?

Nuclei—Nucleoli—Cells considered.

sue. The membrane appears under the microscope to be similar in different cases, but the substances secreted are very numerous, and very different from each other. However simple, therefore, the membrane may seem, its constitution in one case must be different from what it is in another.

294. *The basement membrane* is found just below all the free surfaces of the body, within and without. At certain places it exhibits spots which are called nuclei.

They are called nuclei because they were thought to be the germ of cells. They are also, for the same reason, called cyto-blasts.

295. *The nuclei* are very minute bodies, which sometimes seem to be tiny cells, and sometimes granules. They usually adhere to the membrane, but are sometimes free. The free nuclei are usually the germs of cells. Within the nucleus is frequently seen a spot of an apparently granular character, called a nucleolus.

296. *In considering cells* we must notice several things. 1st. The surface of the cell is composed of simple membrane, which has the property of secreting the cell contents. 2d. The contents of different classes of cells are very unlike. The contents of some cells are formed of a pellucid fluid. In other cases they are viscid. In some cases the cell is partially or wholly occupied with granules. In some cases the contents are horny; in other cases earthy. In most cells a nucleus is to be found adherent to the wall of the cell, being a very minute body, and sometimes filling the cell. 3d. Some cells are very permanent—e. g., the fat cells. Other cells come to maturity, burst, yield up their contents, and are followed by others in a very short time.

In what respects are nutrition and secretion similar and dissimilar? Where is basement membrane found? What are nuclei? Of what is the surface of a cell composed? What appearance do the contents of cells present?

Fig. 54.

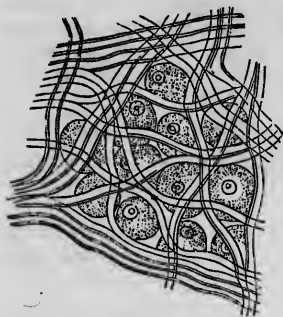


Fig. 55.

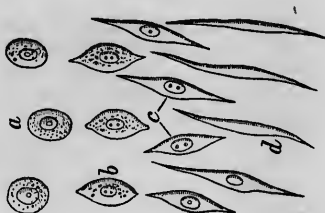


Fig. 56.

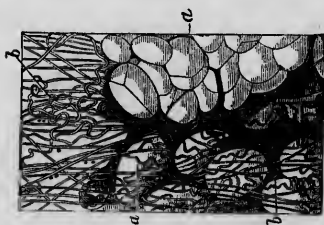


Fig. 57.

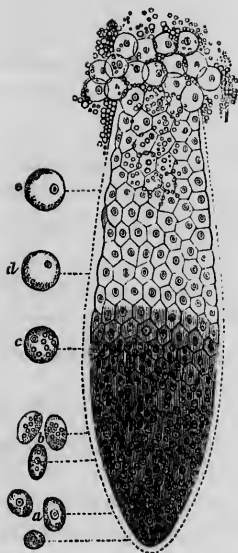
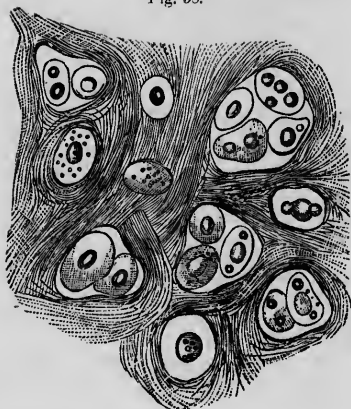


Fig. 58.



For description, see next page.

Describe figs. 54—55—56—57—58.

Fig. 59.



Fig. 60.



Fig. 61.

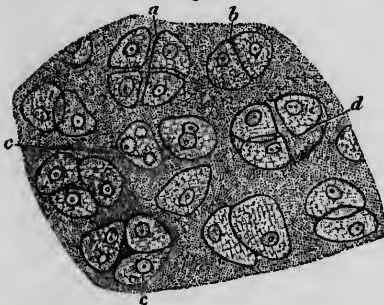


Fig. 54. — Cells, nuclei, and nucleoli of the nervous system.

Fig. 55 represents isolated cells of several forms. *a*, Cells with nucleus, nucleolus, and granules. *b*, Same, except in shape. *c*, Cells with granules upon one side and two nucleoli. *d*, One cell has a nucleus, but the others have none.

Fig. 56. — *a*, Distended fat cells kept in place by the fibres, *b*. No nu-

cleus to be seen. Contents pure ungranulated fat.

Fig. 57. — This gives a view of a follicle, and the development of cells in it. The dotted line may be supposed to represent one side of the basement membrane which extends to the cells, situated upon its inner surface. *a*, *b*, *c*, *d*, *e*, represent the progress of cell development; while above they are crowded from the follicle, and bursting, yield up their contents.

Fig. 58. — Cells, nuclei, and nucleoli of cartilage, surrounded by fibres, producing fibro-cellular cartilage.

Fig. 59. — *a* represents columnar nucleated cells, which at the small extremity rest on basement membrane. *b*, Cilia, which are in constant motion, of a vibratile character.

Fig. 60. — *b* represents the basement membrane of the skin; *c*, a few isolated cells; *d*, the flattened dry cells as they appear at the surface.

Fig. 61. — Cells, nuclei, and nucleoli of cartilage inclosed in inter-cellular substance.

 Cells—Each has a Lifetime.

4th. Some cells are adherent, or are surrounded by tissues which confine them to one place ; while others are free, and move about in the fluids where they live. 5th. Cells are sometimes scattered, or aggregated, as the fat cells. Other kinds of cells are placed by the side of each other, forming a layer. 6th. Between the compacted cells a gelatinous substance, called the intercellular substance (also called the blastema), is found. 7th. The forms of cells differ in different cases. 8th. Some of the cells have certain processes or prolongations formed at their free surfaces. They somewhat resemble an eyelash, and are therefore called cilia (see glossary). They are in constant motion during life, and usually for some time after general death. Their motions are therefore dependent on inherent properties, which are to be added to the other peculiarities of cells.

The cell is one of the most important parts of the whole body. It was by some, at one time, thought that all parts of the body were composed of cells transformed in one way or another. It is certain that all parts are formed from cells as their first origin. In many parts that have no appearance of cells, nuclei are exhibited when proper tests are applied. But it is now certain that the more solid tissues are not nourished by a succession of cells or crops of cells. Such tissues add to themselves substance similar to themselves, at once. But the more rapidly changing tissues are composed of cells or basement membrane.

297. *Each cell is supposed* to have a lifetime of its own—viz., a period of growth, maturity, and decay—the duration of which varies in different parts of the body, in different persons, and under different circumstances.

Inf.—This is an exceedingly important point. It shows that there is a period when the cell should be used, viz., its maturity. The action

How are cells situated in respect to each other ? What is intercellular substance ? Are the forms of cells uniform ? What are ciliated cells ? What is the comparative importance of the cell ? What periods in the existence of cells ?

Periods when Cells should be used.

of any part may be too great or too little for its good. Especially will this apply to the brain. Causes of excitement produce too rapid a change of its parts, and the cells do not mature and perfect themselves. Hence the more frequently the excitement is produced, the more easily can it be. People living in a city, where so many sounds and objects of sight involuntarily act upon the brain, are easily excited. People not accustomed to city life find their minds confused, as their brain cells are not formed as rapidly as habit causes to be done, and they are not accustomed to the action of immature cells, which are ever ready for immature action. Young people educated in the city are apt to appear giddy and flippant for the same reason. On the other hand, too little excitement allows the cells to pass the point of maturity towards decay. The action which results in such a case is prosy and sluggish. A farmer who lives secluded from society is apt to suffer. He who is on the borders of the wilderness, and must exert himself and be on the alert to watch against foes, animals or men, and who indulges in the excitement of the chase, generally exhibits enterprise and is a man of active judgment. It was the times of the Revolution which made the men of the Revolution (and the women too).

It is of the greatest consequence to health and prosperity, that a person adapt his habits to promote the most perfect production, development, and maturity of the cells, especially the nerve cells, and also their most rapid production consistent with their perfection.

298. *The cells which are highly active require* the presence of blood from which to obtain the substances they secrete. Capillary blood-vessels in great numbers are always found in the immediate vicinity of such cells.

299. *Fibrous tissue*, as its name indicates, is composed of fibres, or cylindriciform cords or threads of exceeding fineness, and apparently homogeneous. It serves to bind parts together; and of it two properties are required—great strength, without and with elasticity; therefore,

When should cells be used? What is the effect of frequent mental excitements upon the cells? What the effect of physical exciting causes? What is the effect of constant repose of the cells? What is the effect of blood upon cells?

Fibrous Tissue.

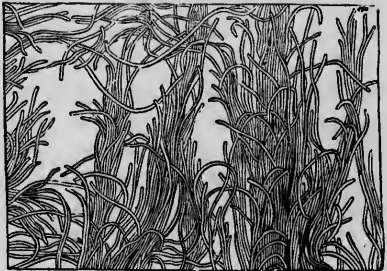
300. *There are two kinds of fibrous tissue*: one the white, inelastic, the other yellowish and elastic. The white usually exhibits the form and appearance of streaked, wavy bands, as in fig. 62. The bands can be made tense by pulling, and yield no more to ordinary force. The yellow exhibits a branched, cordiform, and curly appearance, as in fig. 63.

Fig. 62.



Fig. 63.

301. *Fibrous tissue is chiefly composed of gelatin*. It seems at first to be formed from cells, which elongate, become filled with gelatin, unite with each other, and gradually become fibrous tissue.



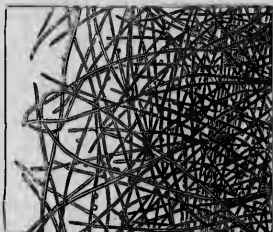
302. *The forms in which fibrous tissue appears in the body differ, according to what is required*. It is formed into ligaments, which are bands or round cords, as the case may be. In the ligaments, yellow or white fibres may be found alone or together. If the force is to act in one direction, the fibres will be nearly parallel. If force is to be exerted in more than one direction, the fibres will be interwoven. The same is true of the tendons and aponeuroses which connect

What is fibrous tissue? How many kinds of fibrous tissue? Describe fig. 62. Of what is fibrous tissue composed? Describe fig. 63. What forms does the fibrous tissue always have? What are ligaments? Of which kind of fibres are ligaments?

Forms in which Fibrous Tissue appears.

the muscles with the parts they act upon. Fibres are also so interwoven as to form what is called fibrous membrane. It is similar to aponeurosis, only there is more interweaving of the fibres, and so as to leave minute meshes. Fig. 64 represents the fibres of the lining of an egg-shell. In these meshes are situated and protected, nerves, blood-vessels, and lymphatics. Such membranes are usually composed of both white and yellow fibres, the elas-

Fig. 64.

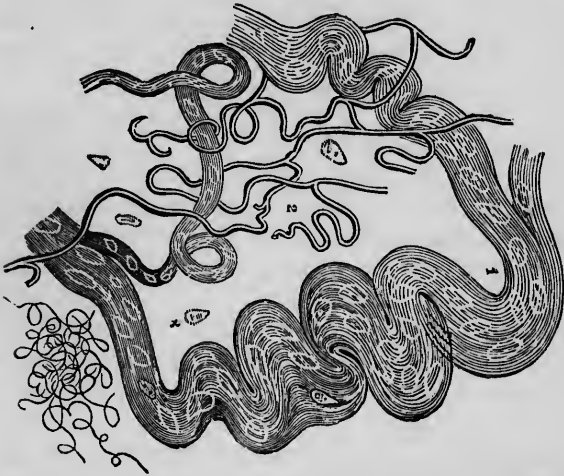


ticity depending upon the proportion of the latter. A thin membrane of white fibres, called periosteum, covers and lines all the bones. A thick one lines the skull; but it has a greater number of meshes than periosteum generally, and is not, therefore, so dense. A fibrous membrane is found beneath all free surfaces—e. g., that of the skin. Another form of fibrous tissue, but one step removed from membrane, is called areolar tissue. It is composed by the intersection and interweaving of the fibrous tissue, so as to form coarse meshes. The white is usually here found in the form of distinct bands, wavy, and more or less intersected and intertwined with yellow fibres, as represented by fig. 65, which represents a very highly magnified portion. The size of the meshes of the areolar fibrous tissue varies very much. This tissue serves to bind parts together, and at the same time allows them to slide over each other to a certain degree, according to the density of the tissue.

What is fibrous membrane? Of which kind of fibres is fibrous membrane composed? Describe the periosteum. What is found beneath all free surfaces? What is areolar tissue?

Areolar Tissue.

Fig. 65.



This tissue was formerly called cellular, and supposed to be entirely distinct from the fibrous membrane, e. g., of the skin. But one is, in fact, a continuation of the other, the change from the large meshes of the areolar tissue to the dense portion near the surface of the skin being very gradual, as may be seen by examining a piece of kid or other kind of leather. On one side (the flesh) the areolar texture is seen; on the other (the grain), the texture is so dense that the surface appears very smooth to the naked eye. In noticing a piece of meat, it will also be seen that the areolar tissue blends with the dense fibrous membranes. This tissue must no longer be called cellular, therefore, as it does not form cells, but areolæ.

303. The forms in which simple fibrous tissue appears are neatly exhibited by the following tableau:—

Aponeurosis, fascia, periosteum, dura mater, fibrous membrane, areolar tissue, are only so many kinds of fibrous membrane, differ-

Are the meshes of areolar tissue similar in size? What is the use of areolar tissue? What was areolar tissue formerly called? Have you noticed a piece of leather and observed whether what the author says is correct or not?

Tableau of Tissues—Cartilage.

ing in density in the order they are mentioned. Indeed, fascia and aponeurosis are the same thing, except in connections.

FIBROUS TISSUE composes	{	LIGAMENT, TENDON, APONEUROSIS, FIBROUS MEMBRANE, AREOLAR TISSUE, FASCIA.
-------------------------	---	---

Compound Tissues.

304. *Cartilage* is the simplest of compound tissues. Indeed, the cellular cartilage is composed of cells and intercellular substance, and might with propriety be considered as a simple tissue. See Fig. 58.

305. *Cartilages are of three kinds*, cellular, fibro-cellular, and fibrous. The fibres are yellow or white, or both, as the case may be. The cellular is composed of cells and intercellular substance. The fibro-cellular is composed of cellular, interspersed with few or many fibres. The fibrous is properly a ligament.

306. *Cartilage exhibits two remarkable properties* combined, firmness and elasticity, the proportions varying as the composition of the cartilage varies.

307. *Cartilaginous tissue* is of a permanent character, and its use does not require that it should undergo changes frequently or very rapidly, while its elasticity would prohibit its being intersected with blood-vessels. The capillaries by which it is nourished exist, therefore, at its surface, or those surfaces where it is not liable to compression.

308. *Cartilage is composed* of that description of gelatin called chondrin.

309. *The constitution of bony tissue* is easily made evident by subjecting one bone to the action of heat, and another

What are the names of some parts composed of fibrous tissue? What is cartilage? Of how many and what kinds are cartilages?

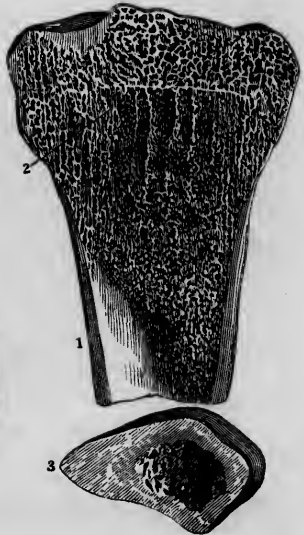
Bony Tissues—Arrangement in Bones.

to the action of diluted mineral acid. The first will become brittle, the second flexible, and may even be tied in a knot. See Fig. 66. They will both retain very nearly their original form, which shows that they are intimately blended throughout a bone. The first part is called the earthy, mineral, calcareous, or hard part. The second is called the animal or flexible, and also the cartilaginous part. The first is composed of the chemical compounds, phosphate and carbonate of lime, with a little magnesium in some cases. The second is composed of fibrous tissue, so arranged as to allow between them very minute meshes, in which the earthy substances are deposited. They are not, however, merely deposited, but combined in some way with the fibrous tissue, not yet well understood.

Fig. 66.



Fig. 67.



Medullary Canals and Cancelli.

310. *The arrangement of the bony tissues* is such as to form four kinds of spaces; two of them are evident to the naked eye, and two are microscopic. If any bone be cut open internally, it will exhibit either irregular spaces called cancelli, or still larger spaces called canals. See Fig. 67, where 1 represents the more solid part of the bone, 2 the cancelli, and 3 a central canal. The cancelli are of various sizes, from very minute to the size of the canal, which is merely an extensive cancellus. The canals and cancelli are lined by serous membrane, which also divides the larger spaces into smaller ones. The whole are filled with fat, called in this case marrow. Hence the name of the cancelli and canals is medullary, or marrow canals, &c.

If a small piece of bone, as the dark part of A., fig. 68,



Fig. 68.



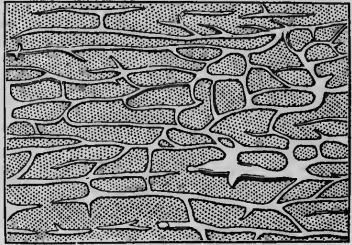
What is the effect of heat upon bone? What the effect of diluted muriatic acid upon the bone? Of what is the earthy part of bone composed? Of what the animal part? How are the two parts combined? How many kinds of spaces in bone?

Haversian Canals—Lacunæ.

be magnified so as to be represented by B., a great number of small canals will be observed, which, from their discoverer, Havers, are called Haversian canals. Fig. 69 represents a longitudinal section of them. They

are lined by simple white fibrous membrane, in the meshes of which blood-vessels and nerves exist for the nourishment and health of the bone. If a few adjoining canals be magnified to a very high degree, exceedingly minute canals called canaliculi will be seen,

Fig. 69.



which open into minute irregular spaces called lacunæ, as seen by fig. 70, in which the Haversian canal is represented surrounded by concentric layers of bony matter, in which the canaliculi and lacunæ are seen in a radiated position; the spaces between the cylinders being filled with matter, and having canaliculi which

Fig. 70.



Describe fig. 69. Describe fig. 70. With what are Haversian canals lined? What are the canaliculi of the bones? What are lacunæ? How are spaces between the Haversian bony cylinders occupied?

Structure of Bone Continued.

communicate with the lacunæ of several cylinders. Through these minute tubes, smaller than hairs, the still smaller nourishing atoms find their way into the midst of what appears to be solid bone, but which is excavated by millions of archways, all so arranged as in the most remarkable manner to give strength in the required direction.

311. *The structure described* is that of every portion of bony tissue, whether belonging to a long or short, a thick or thin bone. The degree of density of the bone varies with the position in the bone, with the bones, and with the age. That is, all parts of the same bone do not have the same density, nor do all bones, nor do the same bones at different periods of life.

Illus. a.—The central part of long bones—e. g., the thigh bone—is very dense, while the ends are much less so. If, indeed, an inch in length be taken from both places, they will, as a usual thing, exactly balance each other.

Illus. b.—The ribs are more flexible than the hips, and those on the left side are more flexible than those on the right.

Illus. c.—The bones of a child are quite flexible compared with those of an old person.

312. *The density of bone depends* upon the degree to which the lacunæ are filled up by deposits, and the degree to which the internal part of the bone is excavated into cancelli.

313. *Bone is remarkable* for combining the three conspicuous properties of inflexibility, strength, and lightness, with a slight degree of elasticity which are exhibited in different degrees in different parts of the body. It is, therefore, adapted to form supports, protections, levers, fulcrums, braces, &c.

What is the use of the canaliculi and lacunæ? What bones and what parts of them contain the canals, &c., just described? Which has the greater diameter, the ends or middle part of bones? Is the flexibility of all bones similar?

Muscular Tissue.

314. *Muscular tissue* is composed of an oblong, cylindrical or flattened sheath, called the sarco-lemma (flesh-sheath), composed apparently of simple membrane, filled with substance called sarcous or fleshy. The whole is called a muscular fibril.

It is also called a muscular fibre and filament, but as the word fibre is appropriated and the word filament is not correctly expressive of the structure, fibril has been chosen.

315. *There are two kinds of fibrils*, called the striated and non-striated (sometimes, but improperly, voluntary and involuntary). The striated, as its name signifies, presents striæ in two directions, as in fig. 71; in the centre of which

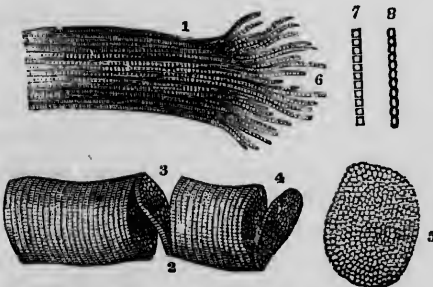
Fig. 71.



the sheath or sarco-lemma alone is seen, the contents having been divided and pulled apart. This appearance is owing to the

arrangement of the contents of the sheath; they seem to be formed of a number of particles, apparently cells, so arranged as to form lines in both a longitudinal and cross direction, as represented by fig. 72. They can be separated

Fig. 72.

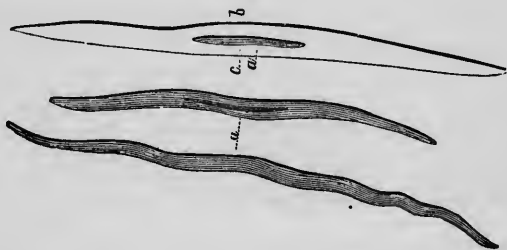


as there seen, so that the contents of the sheath of the striated fibril may be said to be composed either of a pile of discs or of a bundle of fibrillæ. The last, however, seems most proper, for

Production of Muscular Fibrils.

there are certain small animals in which the fibril has been found composed of a sheath enveloping only one row or line of sarcois particles or cells, but I am not aware of any case where a disc is found alone. The striated fibrils are cylindrical, or nearly so. The non-striated are flattened and filled with a substance of a gelatinous consistence, and without any apparent particular arrangement, being called amorphous. See Fig. 73, where *b* represents

Fig. 73.



the sheath, *c* the contents, and *a* the nucleus of the sheath.

316. The fibrils are first produced by the development of a series of cells which, uniting and opening into each other, produce the sheath, which is then filled with substance apparently secreted by the sheath, which may be looked upon as a very large elongated cell.

The size of these fibrils, and the delicate character of the sheaths and their contents, are hardly conceivable by one who is not in the habit of making microscopic observations. The fibril is not as large as the smallest strand of a cobweb. 3,000 of them side by side would hardly measure an inch across! Yet, within one of these, the microscope exhibits to our admiring and astonished gaze great numbers of beautifully arranged fibrillæ.

Of what is muscular tissue composed? What are the two kinds of muscular tissue? Describe a striated muscular fibril. Describe a non-striated muscular fibril. Describe fig. 73. How are the fibrils produced?

Contractility a property of Muscular Tissuo.

317. *There may be some difference* in the elementary composition of the striated and non-striated fibrils, but it is not as yet detectable. The sheaths are probably albuminous. Their contents are fibrin.

318. *The peculiar property* of the contents of the sheath, viz., the sarcous substance, is contractility, or the power of shortening itself, which is only another expression for the fact that the particles of sarcous matter attract each other more strongly and approach each other more closely at some times than at others. Whatever develops this property, viz., acts upon the sarcous substance so as to cause the increased attraction among its particles, is called a *stimulus*.

This power of contracting is inherent in the sarcous substance, and seems dependent wholly upon its composition. This increased attraction of particles for each other is not peculiar to sarcous substance. We see it exhibited by many substances, e. g., iron powdered, when acted upon by a magnetic stimulus, exhibits attraction among particles, and cohesion to a very high degree. Precisely how any stimulus acts upon the sarcous substance, or what effect it first produces, is not yet known; the first effect exhibited is an increased attraction among the parts of the sarcous substance. The apparent effect produced in a fibrilla is exhibited

Fig. 74.



a

by fig. 74, *a* representing an ideal view of the cells of a fibrilla relaxed, *b* the same contracted. Though it may be possible



b

for all the parts of a fibrilla or of a fibril to contract at the same instant, it does not seem ever to take place. A fibril, when observed, exhibits active contraction in only small parts at a time, and only for an instant in any part. So, if the fibril remains contracted for a long time, it is because of the alternate contractions of its parts. These facts account in part for what we see in case of unsteady

What is the difference in the structure of muscular fibrils? What is contractility? Illustrate in some way the attraction which the particles of sarcous substance have for each other? Are all parts of the fibril in action at the same time?

Characteristics of Contractility.

action of the muscles, which is dependent upon improper proportionate contraction of different parts of muscular fibrils.

319. *Contractility exhibits* itself in two ways: 1st, by force; 2d, by extent of motion produced. The degree of force will depend upon the number of fibrillæ which take part in the action. The extent of motion depends upon their length.

320. *The exhibition of contractility* is either dependent upon or associated with corresponding decomposition of the part contracted. The amount of decomposition is therefore dependent upon two things: 1st, the degree of force; 2d, the extent of motion exhibited.*

Inf.—Nutrition of muscular tissue should always correspond with the force and motion exhibited.

321. *The increased and diminished strength* of a fibril must depend upon the increase or diminution of the breadth of its sarcois substance.

322. *The sarcois substance has no power of relaxation*; when contracted it remains so till extension is produced by some opposing cause. This is twofold: 1st. Wherever it is possible, elastic substance is made to oppose and extend the muscle. This is where active and controlled contraction in the opposite direction is not necessary; e. g., when a person curves the back by the contraction of appropriate muscles, they are resisted and extended by the action of the spinal elastic substances. 2d. Antagonistic fibrils are placed where, by contraction, they will extend their opponents; e. g., the muscles upon the front and back of the arm are called antagonistic.

How does contractility exhibit itself? Upon what is the exhibition of contractility dependent? With what must nutrition of the muscle correspond? Upon what does increase of strength of fibril depend?

Areolar Tissue of Muscles.

323. *The sarcoous substance is always* somewhat contracted, or exhibits what is called passive and tonic contractility; e. g., if a muscle is cut, its parts contract, and the wound gapes.

324. *Different parts of the fibril may contract*, so as to produce a shortening equal to two-thirds the length of the parts concerned, but so far as observed, the entire fibril is never shortened more than one-third.

325. *Strictly speaking, the fibril is the essential part of the muscle*, or may be called a muscle. Sometimes it is found alone; usually or always in this case it is the unstriated. This case exists when very slight or diffused action is required; the fibril then exists in the midst of fibres (fibrous membrane or areolar tissue), and adheres to them.

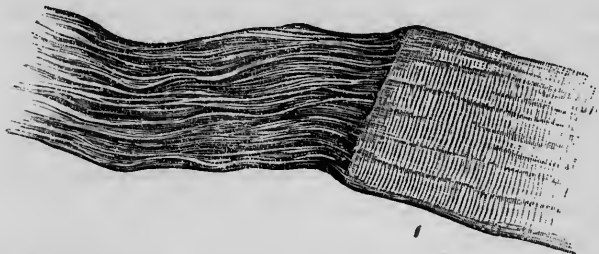
326. *When the action required* is considerable, or must be concentrated on any point, many fibrils will be required, and their arrangement must be such that their single or combined action will gain the desired end. The several fibrils must be enveloped and intertwined with very delicate fibres, for four reasons: 1st, to bind them together; 2d, to separate them and allow them to move upon each other slightly; 3d, to form meshes for the very delicate capillaries which supply the nutritious blood, and the equally or more delicate nerves through which, usually, the stimulus which excites contractility acts; 4th, to connect the fibrils with those parts upon which they are to act.

The blood-vessels and nerves do not enter the fibrils, but exist between them and upon their sheaths. The fibres referred to are usually spoken of as forming a very delicate areolar tissue which

What is tonic contraction of muscular tissue? To how great a part of its length can a muscular fibril contract? What is the essential part of a muscle? What is the use of the areolar tissue of the muscles? Do the vessels enter the fibrils?

Fasciculi.

Fig. 75.



envelopes the fibrils, and forms a bed for the protection of vessels and nerves. Some of the fibres of this tissue extend beyond the fibril, while some are connected to its end, and extend with the others, all of which, if gathered in a cord, form a tendon; if expanded, are aponeuroses. Which form should exist will depend upon whether the muscle should act upon a single point, upon several, or many. See Fig. 75, which represents a bundle of fibrils and the extending fibrous tendon, not, however, condensed as it may be.

327. *Fasciculus* is the name given to the bundles of fibrils. It is covered with fibrous tissue so condensed as to form a membrane, which is called a fascia. The fibrils in a fasciculus are always, so far as I know, parallel, and when active, produce effects in similar directions. Sometimes a single fasciculus composes an entire muscle, but usually a bundle of them is necessary, which constitutes what is called a lacertus, a single one sometimes being a muscle, and sometimes a bundle of lacerti being necessary before a muscle is completed. In the case of all these bundles the same principles prevail, as in forming the fasciculi, viz.: the fasciculi and lacerti are bound together by fibrous tissue and covered with a fibrous membrane or fascia, which is thicker as the bun-

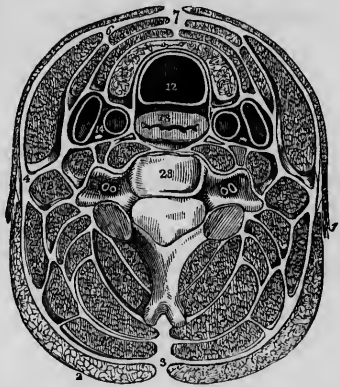
Describe Fig. 75. How are the tendons formed? To what is the name fasciculus given? What are lacerti? What is a fascia? Are the fibrils of a fasciculus oblique? Are the fasciculi always parallel?

Vessels of Muscular Tissue.

dles are larger, till at last, when muscles are formed and bound together in groups, a very conspicuous sheath is formed, which may be seen in any piece of meat, and is conspicuously represented in Fig. 76 by the white lines 3, 4, 6, 7.

Fig. 76 represents a cross section of the neck after the skin is removed. 12. Wind-pipe. 13. Oesophagus. 14. Blood-vessels surrounded by loose fibrous or areolar tissue. 28. Body of a cervical vertebra, back of which is seen, 1st, the spinal canal; 2d, the spinous process; on each side of the canal are seen the articulating processes; between those and the body, the vertebral artery and vein are seen in the lateral processes.

Fig. 76.



Between the bundles the larger blood-vessels and nerves are found. The sheaths of the fasciculi, lacerti, and muscle, with some of their intervening fibrous tissue, extend beyond the fibrils to assist in forming the tendon.

328. *The fasciculi are sometimes parallel, but more frequently not. They are not usually of similar length. In this respect they are so adapted that their length and position are always harmonious. That is to say, when the different fasciculi of a muscle contract to a similar degree of the length of each, the extent of motion of the point to which they are attached will be precisely the same by the action of each, which is a very striking illustration of the wonderful*

What is found at the surface of muscles? Describe Fig. 76. Where are the larger nerves of a muscle found? Are the fasciculi of similar length? What is the effect of unequal length of the fasciculi? Of what is this a striking illustration?

Nervous Tissues.

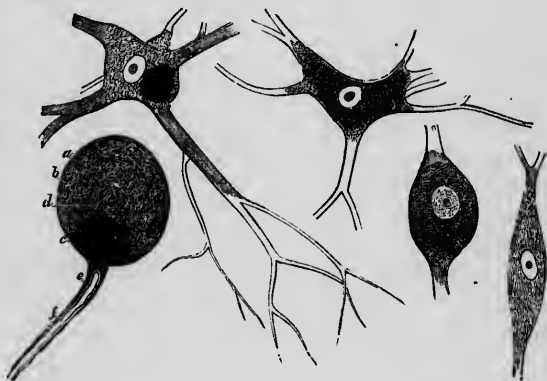
yet simple mechanical arrangement which is found throughout the whole body.

Nervous Tissues.

329. *There are two kinds of nervous tissue—one called the vesicular, gray, cineritious and gelatinous; the other, the fibrous.*

330. *The vesicular is composed of cells interspersed through a granular, gelatinous, intercellular substance. The cells are composed of an apparently amorphous membrane like basement membrane, filled with a gelatinous, granular substance. There is a nucleus adherent to the inner surface of the cell, of the same apparent character as the cell itself. The nucleoli is a very brilliant and conspicuous spot. The form of the cell is usually spherical, but*

Fig. 77.



What are the two kinds of nervous tissue called? Of what is the vesicular composed? In what is it found? Of what are the cells composed? Of what organic element is the membrane of the cell composed? Have the nervous cells nuclei and nucleoli?

Pacnian Corpuscles.

in many cases it exhibits processes or appendages more or less branched. See Fig. 77.

331. Nervous fibres are of two kinds, the white and the gray. The white are composed of an outside sheath or tube similar in appearance to the sarco-lemma of muscles. Within this there is a layer of white substance called the white substance of Schwan. The centre of the nerve is occupied by a pale transparent substance called the axis cylinder. The gray fibres, called also the gelatinous, are composed of a very delicate sheath inclosing a substance apparently similar throughout.

332. It is proper here to draw attention to a very curious thing connected with the nerves, and called from its discoverer Pacinian corpuscle. It had escaped notice until very lately. Fig. 78 represents it magnified; it is about as large as a hemp-seed, and composed of 40 to 60 capsules, as the layers are called. The inner third of these seem to touch each other; the outer ones are separated by fluid. The nerve enters at one end, and,

Fig. 78.



Of how many, and what kinds are nervous fibres? Of what, and how are the white fibres composed? What is a Pacinian corpuscle? Where are Pacinian corpuscles found most abundantly? Describe fig. 78.

Nerves—Constitution of Nervous Substance.

losing its sheath and white substance, its axis cylinder passes directly through and terminates in a bulb, which adheres to the inner capsule; or it passes through the capsule, exhibits again the white substance and sheath and enters another. The properties or uses of these corpuscles are not known as yet; they exist only on nerves of sensation, and especially abound on those of the hand and foot. It is surprising that they were not noticed before they were.

333. *Nervous fibres are gathered into bundles*, which are interwoven by fibrous tissue, blood-vessels, and inclosed in a fibrous-membrane sheath, which is called a neurilemma; the whole constitutes a nerve, which is larger or smaller, according to the number of fibres composing it.

334. *Nervous substance is very highly compounded*; it is composed chiefly of water and of other substances, as follows, according to Vauquelin:

Albumen -	-	-	-	-	-	-	7.00
Cerebral fat -	-	-	-	-	-	-	5.23
Phosphorus -	-	-	-	-	-	-	1.50
Osmazome -	-	-	-	-	-	-	1.12
Acids, Salts and Sulphur -	-	-	-	-	-	-	5.15
Water -	-	-	-	-	-	-	80.00
							100.00

The proportion of phosphorus is very noteworthy—one twelfth of the solids; its minimum is said by L'Heritié to be found in infants, old persons, and idiots, which is a very significant fact.* The following is his table:

* Students and all who wish to task the brain, will perceive or infer that a large amount of food highly phosphorized should be eaten. They are by appetite, indeed, inclined to eat such food, but do not always appreciate the importance of pleasing themselves in this respect.

What are the uses of Pacinian corpuscles? How are nerves formed? Do blood or other vessels enter the sheath of the nerve fibre? Of what is nervous substance composed? What is especially noteworthy?

Composition of Nervous Substance.

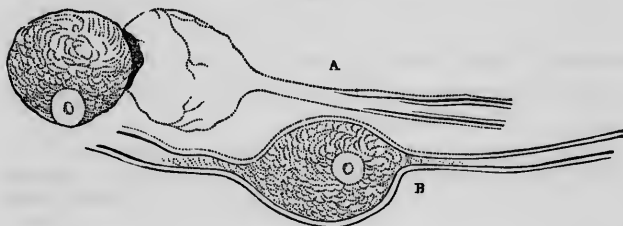
	Infants.	Youths.	Adults.	Aged.	Idiots.
Albumen	7.00	10.20	9.40	8.65	8.40
Cerebral fat . . .	8.45	5.30	6.10	4.32	5.00
Phosphorus . . .	0.80!	1.65	1.80	1.00	0.85!
Osmazome and Salts	5.96	8.59	10.19	12.18	14.82
Water	82.79	74.26	72.51	73.85	70.98
	100.00	100.00	100.00	100.00	100.00

I am not certain whether the above tables compute the phosphorus as excess above what belongs to albumen, or as the whole found in nervous substance; but I conclude it is the excess.

Inf.—It would at once be inferred that food containing phosphorus in abundance would be needed by students and all those who use the brain actively.

335. In many parts of the body the white nervous fibres, and in some the grey, are found by themselves; in some the fibrous and the cellular are found together, constituting what are called ganglions or ganglia, also nervous centres. Some of the fibres seem to communicate with the cells, as seen by fig. 79, where A represents a cell removed from the delicate membrane continued over it from the fibre, and B represents a cell inclosed by a nerve sheath which extends beyond it.

Fig. 79.



In what persons does phosphorus most abound? What substances vary most in their proportions in idiots compared with others? Are the white and gray fibres found together or alone? What relations have the fibres to the cells?

Properties of Nervous Fibres.

Fig. 80.

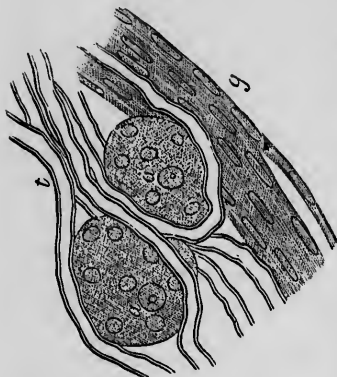


Fig. 80 represents white *t*, and *g* grey fibres in the midst of cells and in contact with them.

336. The white and grey fibres interlace with each other in various parts of the body, producing plexuses. The fibres are never, however, broken up in such a case; but those of different nerves are interchanged, and also new nerves produced.

337. The properties of the different fibres cannot be accurately distinguished as yet; they are supposed to be wholly internuncial—that is, communicators—for they stretch between the nervous centres and all parts of the body. In this respect they are of two kinds; one through which influences are exerted, from the various parts of the body, upon the nervous centres; and another through which influences are exerted in the opposite direction. No examination of the tissues of each with the eye, with the microscope or chemically, could determine the uses or properties of each. Experiment has confirmed what the nature of the case would suggest.

How any influence is exerted through the nerve, and what effect it has on the nerve, has not yet been detected. All we know is, that the nerve fibre has the property of communicating influences.

Describe fig. 79. Describe fig. 80. What is a plexus? What are the offices of the nerves? What two kinds of nerves are there? What is all that is yet really known of the functions of the nerves?

Properties of the Cellular Nervous Tissue.

338. The property of the cellular nervous tissue, is to produce sensations in the mind, and to produce an influence which, acting through the nerves, will stimulate the muscles to contract. What properties the cells have in respect to what are called powers of the mind, is not known.

It is probable that the cells of the centres secrete their contents, and, bursting, yield them up to form the granular mass, in the midst of which the cells exist; or it may be that the mass is first prepared, and from it the contents of the cells secreted by the cell. One thing is certain, the cells are constantly being reproduced and developed, and are active agents of great consequence in operations carried on by means of nervous substance. A single cell may, it is believed, be looked upon as a centre. The active changes taking place in the centres, require the presence of a large supply of blood, which is freely furnished to the brain, which is only one fortieth the weight of the whole body, receiving one sixth of the blood. The nutrition of the nervous substance—its excretions—a proper supply of food and oxygen for it—are matters of great consequence.

Compound Membranous Tissues.

These are not properly called tissues, but organs—e. g., the skin is certainly an organ. Why, then, should the mucous and serous membranes be called tissues? And why should blood-vessels and lymphatics be called tubular tissues? We have also “glandular tissues,” which seems to me an improper use of words or ideas, or both. The skin, mucous and serous membranes are compound membranes, being composed of three strata—the cellular, basement, and fibrous membranes or layers. In the meshes of the fibrous, three kinds of parts are found—blood-vessels, lymphatics, and nerves. There may, or may not, be some muscular fibrils or fasciculi in the fibrous membrane. The tubular tissues are composed of serous membrane; the most minute are formed of the basement membrane alone, or of that lined with cells. As the tubes become larger, the fibrous is added, and its peculiar character varied as the organ it composes requires. Glandular tissue is

What are the properties of the cellular nervous tissue? Are the cells permanent? What may even a single cell be considered? What proportion of blood does the brain receive? How many strata has the skin?

Humors—Blood—Corpuscles of Blood.

essentially the same as the mucous or serous membranes; the object in a gland being to increase the extent of surface of the cellular and basement membranes as much as possible, and to supply them very freely with blood. The amount of fibrous tissue in a gland is not usually very great. Glands, vessels, and compound membranes are to be considered as organs.

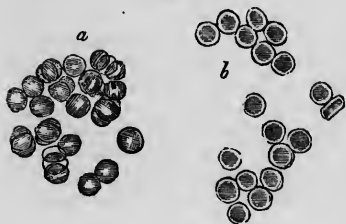
Humors.

339. *Humor* is only another name for fluid, of which there are several varieties in the body. The blood is the chief humor. Next to blood the serous fluid is greater in quantity than any other; there are also fat, mucus, tear-fluid, saliva, gastric juice, pancreatic juice, bile and gall, the renal secretions, and lymph and chyle.

340. *Blood* is chiefly composed of water, which weighs from seven to nine tenths of the whole. The solid portions of the blood are dissolved or suspended in the water. The solid portions of the blood are obtained from three sources, the food, the air, and the decomposing tissues of the body. The solids are therefore divisible into the formative and secondary compounds, as already pointed out. But the blood is also in part composed of secretory tissue.

341. *There are floating in the blood* thousands of minute cells called corpuscles.

Fig. 81.



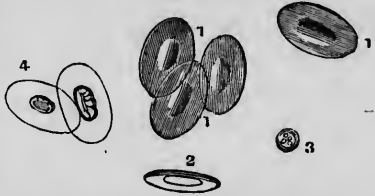
Of these there are two kinds, called the red and white. They have the appearance of discs, as seen by fig. 81. In a fowl they are elliptical; see fig. 82. When viewed edgewise they sometimes

What is the object of a gland? What is a humor? What is the most abundant humor in the body? Of how great a proportion of water is blood composed?

Character of Blood Cells.

appear convex, but usually slightly concave, according to the fluids with which they are in contact. The color of the red corpuscles is sensibly affected by rendering the concave sides of the corpuscle convex. The red corpuscles contain globuline and hæmatosin. The white corpuscles are in health in the proportion of only about one to fifty of the red. The white are filled with a white, slightly granular, gelatinous substance, the precise composition of which has not yet been ascertained.

Fig. 82.



Some have supposed that the red corpuscles were produced from the white, but this does not seem to be the case. The white are similar, and as Paget declares, identical with the white corpuscles of the chyle and lymph. In disease the white cells may increase in number so as to be in proportion to the red as one to ten. The precise use of these cells is not yet fully understood. They may very properly be compared to vegetables. They have neither contractility nor sensibility. The yeast-plant is a single cell like the blood-cell. Vegetables secrete substance which is useful as food for animals. It is supposed that the blood corpuscle secretes substance which is useful in nourishing the tissues. The cells develop and fill themselves from the blood in the midst of which they are, and having matured, burst and yield back in a perfected state the substance they removed. They may therefore be looked upon as portable vegetables. Through their action it may be that various elements, received from the decomposing tissues, are prepared so as to be of some use. It may be, on the other hand, that they live entirely at the expense of the blood, yielding back to it only excrementitious matter. Some have also supposed that they were carriers of oxygen, which combined with the iron, a conspicuous component of hæmatosin.

What is the effect of rendering the corpuscles convex? Which are more numerous, the red or white corpuscles? To what may the cells be compared? Why may the cells be considered as portable vegetables?

Coagulation of Blood.

342. *The corpuscles are so exceedingly minute that they freely circulate through the smallest capillaries, presenting a beautiful appearance beneath the highly magnifying microscope as illustrated by fig. 83, where 2 represents capillary tubes with a crowd of blood cells passing through them.*

Fig. 83.

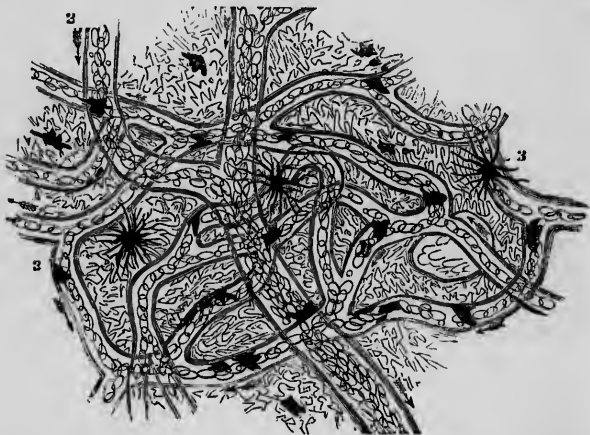


Fig. 83.—Capillaries very highly magnified. Tissue is seen between, and the corpuscles within them. Arrows indicate the direction of the current. 3, dark pigment cells in the tissue. Sometimes the corpuscles seem to be attracted to the sides of the tubes, and adhere to them or move slowly along.

They can therefore exert their influences upon the delicate tissues of every part of the whole body.

343. *If blood be allowed to stand it will naturally coagulate, the clot being at first equal to the volume of the blood. In a little time the clot contracts and expresses from itself*

With what parts of the blood do some think that iron combines? What is the size of the corpuscles compared with the capillary blood-vessels? Describe fig. 83. What influence can the corpuscles, as carriers of oxygen, exert upon the tissues?

 Constituents of Blood.

a pale yellowish slimy fluid called serum. The clot is composed of fibrin and the corpuscles entangled in it. By washing, the corpuscles can be removed, and the fibrin obtained. The upper part of the clot is apt to appear of a buff color, and is called the buff coat. The reason of this is, that before the clot is formed, a part of the corpuscles begin to fall and leave fibrin only, which, contracting, also gives a "cupped" appearance to the surface. The serum is composed chiefly of water and albumen, but in part, of all the other constituents of the blood except fibrin, globuline, and hæmotosin. The following tables exhibit the proportions of, 1st, the principal, and 2d, all the constituents of the blood.

WATER,	784.	
CORPUSCLES,	131.	
ALBUMEN OF SERUM,	70.	
SALINE MATTERS,	6.03	
EXTRACTIVE, FATTY, AND OTHER MATTERS, .	6.77	
FIBRIN,	2.2	
	<hr/>	1000.00

WATER,	784.	
ALBUMEN,	70.	
FIBRIN,	2.2	
GLOBULINE,	123.5	
HEMATIN,	7.5	
CHOLESTERINE, CEREBRINE, SEROLINE, OLEIC AND MARGARIC ACIDS, VOLATILE AND ODOR- OUS FATTY ACID, FAT CONTAINING PHOS- PHORUS,	1.3	
CHLORIDE OF SODIUM,	3.6	
CHLORIDE OF POTASSIUM,	0.36	
TRIBASIC PHOSPHATE OF SODA,	0.2	
CARBONATE OF SODA,	0.84	
SULPHATE OF SODA,	0.28	
PHOSPHATES OF LIME AND MAGNESIA,	0.25	
OXYDE AND PHOSPHATE OF IRON,	0.5	
EXTRACTIVE, SALIVARY AND BILIARY MATTER, } UREA, GASES, AND ACCIDENTALS,	5.47	
	<hr/>	1000.00

Serous Fluid—Fat—Mucus.

344. *Serous fluid* is divisible into several different kinds, according to its composition and the places where it is found. Synovial and bursal fluid are very similar to each other. The fluid moistening the areolar tissue is another variety. It is not formed by serous membrane, but seems to be an exudation through the capillary vessels. The fluid of the cranial and spinal membranes is slightly peculiar. That of the serous membranes of the chest and abdomen would form another variety. All of these varieties of the serous fluid are composed chiefly of water with a little albumen and some of the salts of the blood mixed with it.

345. *Fat* has already been described. It is a fluid at the ordinary temperatures of the body. It is a component of the blood and of the nervous tissues, and is stored up in cells which collectively are called adipose tissue.

346. *Mucus* is a white or slightly yellowish, peculiarly viscid fluid. It does not readily mix with water. It is, nevertheless, composed chiefly of water, only about four to six of its parts being solid; these are partly composed of salts, but mostly of a peculiar albuminous substance called mucin, which gives to mucus its prominent characteristic. It is formed in the epithelial cells of the mucous membrane, and under the microscope shrivelled cells and parts of cells are conspicuously seen in the mucus. It protects the passages it covers from the action of irritating substances.

The other humors are special, and had better be described with the parts by which they are produced, or where they are formed.

What is the coagulated clot of blood composed of? What is the buffy coat of the blood? Of what is the serum of the blood composed?

Into what varieties might serous fluid be divided? Of what are all chiefly composed? Describe fat. What is mucus? Where is mucus formed? What is its use?

What is the word system used to denote? Describe figs. 84, 85.

CHAPTER IV.

Systems—Simple and Compound Organs.

347. *The word system is used to signify the entire collection of any kind of tissue found in the body; e. g., the*

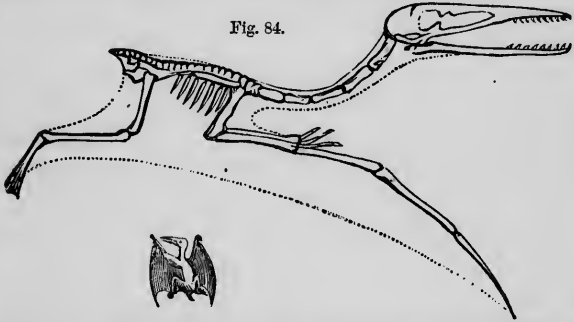


Fig. 84.

Fig. 84. Representation of Pterodactylus and outline of membranous wings.

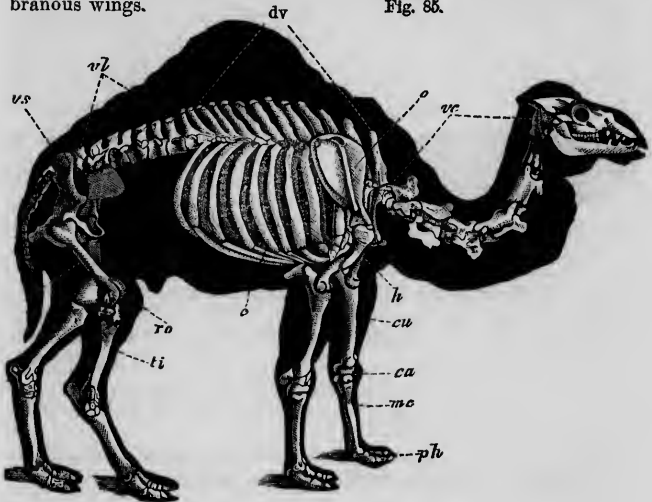


Fig. 85.

Fig. 85 represents the framework of the camel; *vc, vd, vl, vq,*

Compound Systems.

bony system of an animal embraces all the bones, as illustrated by figs. 84 and 85.

348. *There are simple and compound systems, corresponding to the simple and compound tissues. The simple systems are the cellular, the simple membranous, and the fibrous.*

It has been seen, that, properly speaking, the cellular and simple membranes are composed of the same tissues, but the contents of the cells and their almost infinite number seem to entitle them to a name, and to consideration. It is not usual to include the intercellular substance, nuclei, nucleoli, or granules among the tissues, and they are not, therefore, included among systems.

349. *Compound systems embrace the bony, cartilaginous, muscular, and nervous.*

It is also usual and proper to use the word system to denote the whole of any variety of the grand systems; e. g., tendinous system includes all the fibrous system that is in the form of tendons. There are, also, the ligamentous system, the aponeurotic system, the sensory, the motory, ganglionic, nervous systems, the ner-

Fig. 86.



vous systems of organic or animal life—all of which, and others, are not only proper but exceedingly convenient, for the characters or uses of the organic and relational nervous systems are very different. In the lower animals the first only exist, as in fig. 86, where the white spots represent the organic ganglia, and the white lines

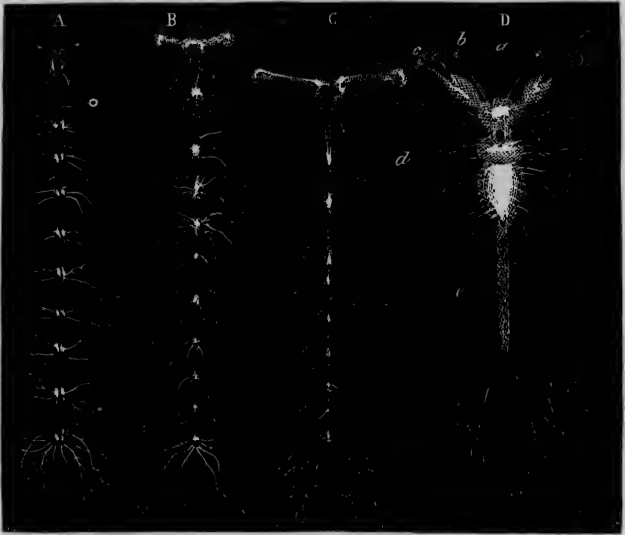
the connecting nerves; and it is desirable to compare the systems of different animals, as in fig. 87, where, from a very simple nervous system at A, we pass to one of a much higher character at B.

cervical, dorsal, lumbar, caudal vertebræ; *vs*, sacrum (sacral vertebræ); *o*, scapula; *p*, humerus; *cu*, radius; *ca*, carpus; *mc*, metacarpus; *ph*, phalanges; *c*, ribs; *fe*, femur; *ro*, patella; *ti*, tibia; *ta*, tarsus; *mt*, metatarsus.

Describe fig. 85. Why is the cellular tissue distinguished as a tissue? What do compound systems embrace?

Lymphatic, Arterial, Glandular, &c. Systems.

Fig. 87.



The use of the terms lymphatic system, arterial system, glandular system, is only allowable with a protest or explanation. They are used because all organs include blood-vessels among their components; most include lymphatics and nerves, while the simple glands are structural components of quite a number. The word tissues is applied to the same parts, for the same reason. A short explanation is all that is needed. By arterial system is meant the entire arteries of the body; of which, in fact, there are only two, each of which is composed of a great number of branches to which the name of artery is given, but it is only a part of the whole to which it belongs. The two arterial systems do not directly communicate, but are perfectly distinct. One is called the systemic, and the other the pulmonary. The branches of the systemic are distinguished by their situation or the organ to which they lead. The last applies to the entire length of the branch; the

Describe fig. 86. What does fig. 87 represent? Why are not the terms lymphatic, arterial, and glandular systems proper? What is meant by arterial system?

Glandular Systems.

first, usually, only to a very short portion of it—e. g., hepatic artery, renal artery, or hepatic systemic, &c., which gives the specific precedent to the generic name. The pulmonary arterial system is divided into the right and left. The capillaries of the body are also embraced under the head of capillary systems, and the distinguishing names are, pulmonary and systemic; of which last there are the divisions, renal systemic, cerebral systemic systems, &c. The venous systems are threefold—systemic, pulmonary, and portal systems. The portal system embraces those veins which lead blood into capillaries. The expression lymphatic system embraces usually two classes of parts, the lymphatic tubes and lymphatic glands. Of each there are two kinds, the lymphatic proper, and the lacteal, which is a branch of the lymphatic, but they are spoken of as distinct—viz., lymphatic and lacteal systems. The glandular system embraces all the glands of the body, which are usually divided into four classes or systems—the open glands, the lymphatic glands, the vascular glands (as, however, this last is not a distinguishing name, I shall call them closed glands), and the floating glands.

A cell is the simplest form of a gland. But as a single cell could accomplish but little, they must be aggregated; and for this purpose a peculiar formation is necessary, as well as to bring blood freely into their immediate vicinity. In the blood there can be great multitudes of them without any attachment, because they are in the blood from which they are to secrete. When a mere pouch, crypta or follicle, or papilla or villus exists, for the purpose of giving room for cells in a small cubical space, there is formed a very simple gland. When several of these open into one tube, a composite gland exists. When there are a great number of these packed very closely, there is formed an aggregated gland. When the tubes of these open upon any free surface, viz., upon the skin, mucous or serous membrane, an open gland is formed. Of these there are the following:—Oil or sebaceous, ceruminal, and perspiratory glands of the skin; meibomian glands of the eyelids; lachrymal or tear glands; mucous follicles of the mucous membrane; salivary glands; amygdaloid glands of the throat; gastric glands or follicles of the stomach; the pancreas; the liver; Brunner's Peyer's, and Leiberkuhn's glands of the second stomach; and the kidneys.

The lymphatic glands are in very great number throughout

How are the branches of the systemic artery distinguished? How is the pulmonary arterial system divided? How are the capillaries distinguished? What are the primary divisions of the venous systems? What does a portal system embrace? What does the lymphatic system embrace? How many kinds of glands in the body?

Lymphatic Glands—Closed or Vascular Glands.

most parts of the body. Fig. 88. 5 represents a few which are connected with the lacteals, extending from 7, 6, 4, the second stomach, to unite and form 1, which will lead its contents into the blood-vessels. Fig. 89 represents a section of a gland, in which a great multitude of cells exist, which, developing partly at the expense of the blood contained in the capillaries of the lymphatic glands, and partly at the expense of the lymph in the lymphatic vessels, at last either burst and yield their perfected contents to form part of the lymph, or become loosened from their places and float away with the lymph and as part of it.

The closed ganglia are somewhat like lymphatic glands, except that no special tubes open into or from them, and that they are in man much larger. Like them, they are divided by areolar tissue into many small compartments, which are filled with cells; supposed to be constantly undergoing development, secreting their contents, and yielding them perfected back to the blood whence they came. Special tubes are not necessary. The blood-vessels are

Fig. 89.—Enlarged gland, with a single tube leading into and from it. Fig. 90.—Less enlarged gland with several tubes p, leading into, and 2, from it; c, blood-vessels.

Fig. 88.

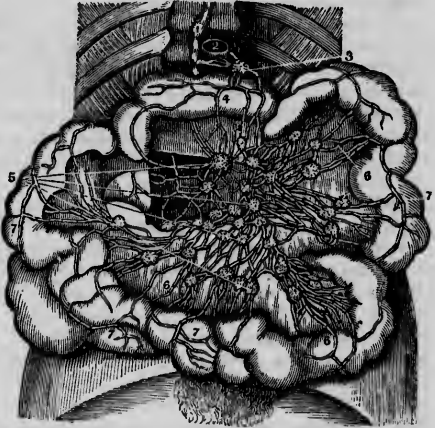
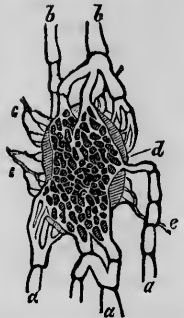


Fig. 89.



Fig. 90.



Describe fig. 88. What are represented by figs. 89 and 90.

3 B.—9.

Properties of Systems—Organs.

sufficient; and the number of these is so great, that the glands have been called vascular glands. Why the cells may not float about with the blood, as well as the corpuscles, cannot as yet be explained. It is, by some, thought that the red corpuscles of the blood were first produced in the closed glands, as it is thought the white corpuscles are in the lymphatic glands. The closed or vascular glands are, the spleen, thyroid, thymus, and supra-renal glands. It is seen that closed gland is not a perfectly proper name to apply to these parts of the body, as they are not closed, but are open to blood-vessels which lead into and away from them. It is also probable that the liver is a mixed gland. It is surely an open gland, but probably, throughout the liver, the elementary parts of a closed gland also exist. The two parts have not yet been unfolded, but the uses of the two are constantly exhibited by the liver, as will be shown. Of the blood cells as glands, nothing more need be said. The glands, it will be perceived, may not very inappropriately be compared to vegetables. They have no contractility, and the essential part of them is devoid of sensibility. Indeed, they might be called vegetables without straining a point very much. Their use is purely vegetative, viz., secretory. To have a clear view of glands and their simplicity, however much they may be convoluted, is to take away much of the incomprehensibility and tedium of physiology. It should therefore be farther remarked, that the cryptæ of a gland are sometimes composed of the basement membrane alone, which, like that of cells, has the property of secreting, at least in such cases. It is the essential part, therefore.

350. *The properties of systems* are the same as those of the tissues composing them.

Organs.

351. *An organ is a piece of apparatus* constructed from tissues for action or to be acted with, and adapted to some particular use or uses.

The tissues found in an organ will depend on the uses to which it is to be applied; and, the use being known or premised, the tissues of which it must be constructed are selected accordingly.

What are closed glands? What is supposed in respect to the cells of closed glands? Why are special tubes unnecessary? What kind of a gland is it probable the liver is? To what might the glands be compared?

The structure of Organs.

If it is desirable to construct an organ, the use of which shall be to move any fluid rapidly through its course, the first thing would be to select a tissue adapted to form a pouch or tube. If the fluid, like blood, should be unirritating, a serous membrane would be the proper tissue. If the fluid were the air, a mucous membrane must be selected. If the fluid must be forcibly and suddenly expelled, muscular tissue alone must be added for the purpose, and nerves connected with it; the muscular tissue must surround the serous pouch except at the place of entrance and exit of the fluid. If the contraction of the muscular tissue is slight, and produces but slight motion of itself, it may be connected with surrounding parts by areolar tissue; but if the motion is considerable, the organ must be so made as to slide upon the surrounding parts. This is accomplished by having its outer layer composed of serous membrane, which must also be found at the surface of whatever the organ rests against. Thus is it with the heart; it is composed of three coats; the inner and outer are serous, and the middle is a thick muscular coat. As the fluid should always pass in one direction, there should be valves at each orifice always opening with the course of the blood. As the heart acts forcibly, these valves must be strong and inelastic, and therefore composed of white fibrous tissue. The stomach requires many of the same tissues as the heart; but, as its inner surface must be acted on by food, &c., it must be composed of a mucous membrane; as its contents are never to be acted on very forcibly, its muscular coat should be thin; its outer coat should be serous (see fig. 49); as its contents must sometimes pass backward through the stomachic openings, the valves must not be tendinous, but composed of ring or sphincter muscles. The diaphragm is chiefly muscular, and designed to produce extensive motion on either side; and as it is in contact with other parts, and not with the air or food, &c., its surfaces must be composed of serous membranes. It is an expanded compound membrane, separating the chest from the abdomen; it does not require any valves. The following tableau compares the three organs synoptically, and shows how nearly different organs agree, and that their dissimilarity is owing to the uses to which they are to be applied, on account of which different tissues were necessarily employed in their structure.

What kind of tissues should be used in the structure of an organ? To contain a fluid, what tissue should be selected? To forcibly expel fluid from a pouch, what tissue should be used? What should the outer part of the heart be?

Simple and Compound Organs.

HEART, A POUCH HAS	{ AN INTERNAL, A MIDDLE, THICK, AN EXTERNAL,	SEROUS MUSCULAR SEROUS	{ COAT, and is supplied with FIBROUS VALVES.
STOMACH, A POUCH HAS	{ AN INTERNAL, A MIDDLE, THIN, AN EXTERNAL,	MUCOUS MUSCULAR SEROUS	{ COAT, and is supplied with SPHINCTER MUSCLE VALVES.
DIAPHRAGM, AN EXPANDED COMPOUND MEMBRANE HAS	{ AN UPPER, A MIDDLE, MEDIUM, A LOWER,	SEROUS MUSCULAR SEROUS	{ COAT, and is without VALVES.

352. *A simple organ* is rather imaginary than real; it embraces those parts of an organ which form it, and render it fit for action, such as we have considered above, in case of the heart and diaphragm.

353. *A compound organ* includes not only the tissues which form it for action, but also those by which it is kept in a condition for action, viz., blood-vessels, lymphatics, simple glands, &c.

Of course its growth and first existence is dependent on the receipt of blood, but we may easily and properly abstract in our minds the essential parts of an organ, by which it is fitted for action, from those which are common to all organs, as the blood-vessels, since they serve a property common to the tissues of all organs, viz., nutrition. The essentials of the heart are the serous and muscular coats; and, when we are considering in special or descriptive Anatomy and Physiology the action of the heart, we pay little attention to the arteries, capillaries, and veins, which are in almost infinite numbers distributed among the muscular fasciculi and fibrils of this organ. Indeed it will be found that in the coats of these very minute arteries, vessels, especially capillaries, exist for the purpose of nourishing them. A compound organ is, therefore, composed of what may be called its own tissue, and also of repairing organs, which vessels are also composed sometimes of still more minute repairing organs. Like a beautiful watch, the principles for constructing which are exceedingly simple, but its works so minute, compact, and interwrought, that the child looks at the results with astonishment, and sees no plan in what it is gazing upon; so is it with the human body, built up by the Supreme Architect of the Universe with Divine perfection.

What are the resemblances, and what the differences between the heart, stomach, and diaphragm? What is a simple organ? What is a compound organ? What are the essentials of the heart? Of what is a compound organ composed?

Heat—Temperature of Tissues.

Its various parts seem an inextricable confusion to gaping ignorance; but, when unfolded by the Physiological Anatomist, microscope in hand, they exhibit in the strongest light that simplicity of means which, more than any thing, characterizes infinite wisdom, and awakens in the heart inexpressible emotions of reverential awe and love towards that Being whose attributes humanity can but dimly perceive—never fully appreciate.

CHAPTER V.

Heat, Light, Electricity—Food, Air, Water, Blood, Heat.

354. *The perfection* of the tissues and the exhibition of their properties, requires a certain temperature—the importance of which increases as we ascend the scale from nutrition through contractility to sensibility.

The requirements of the tissues in different parts of the body are not similar, as the following tableau exhibits:

Brain, 96°	Stomach, 100
Throat, 98°	Hands, 94
Heart, 101°	Feet, 92

These degrees are not absolute and invariable. The general principle is, however, correctly exhibited. That temperature of one part which will cause pleasant sensations, will, through another, cause chilliness or unpleasant sensations of heat. The whole nervous system is particularly sensitive to irregularities of temperature; and, to preserve a proper temperature therein, is one of the most imperative duties of life.

Illus. If the head becomes hot, the ideas become confused; when it is cooled again, the mind becomes clear.

As much pains should be taken to lower the temperature of any part, if too high, as would be to raise it, if too low.

Illus. A cool wet cloth laid for a little while upon the heated head of the diligent student, will allow him to sleep, when other-

How do the parts of the body appear when unfolded by the anatomical physiologist? What does the perfection of the tissues require? What are the healthful temperatures of different parts? Is the temperature of each part uniform?

Sources of Heat.

wise he might toss about for hours, growing more weary instead of obtaining refreshment. I will again repeat, that, in sickness or health, one thing of prime importance is to produce a healthful temperature of all parts of the body; without it, a healthy action of the tissues cannot take place—it is a *sine qua non*.

355. *Heat* is received from without, and is produced within the body.

356. External heat is received from two sources—the sun, and artificial sources.

Whether there is more than one cause of heat is not certain. Either there is, or the attendant circumstances with which its influences are exerted, make it appear to produce different effects in different cases. The genial effect which is produced by the pleasant spring or summer's sun is decidedly preferable to the same effect produced by the same temperature artificially obtained. Radiated heat is far more favorable than heat which has been conducted, and the heat of wood is preferable to that of coal.

357. *Heat produced in the body* is the most favorable to health, and promotes also the happiness of any person in no small degree.

Whether it is because the heat differs in kind, or because it is more perfectly diffused through the system, it matters not; every one has felt the advantageous effect of thoroughly warming the body within its own means. It is the proper way. A person feels and is much better who produces and preserves his heat by proper means.

358. *The action of all parts of the body* seems to result in the production of heat.

The common experience of every one demonstrates this proposition. Experiments have, however, been tried upon muscles in particular. It was found that their temperature always rises when they contract. This may arise from several causes. 1st. The contraction of the muscular fibrils and fasciculi would cause some friction and forcible compression of the parts, and thus heat might be

Where are the sources of heat found? Do similar degrees of heat produce similar effects, either sensations or healthful influences? Why should heat be produced in the body? What is the effect of action in the various parts of the body?

Sources of Heat.

caused. 2d. The action of the muscle causes an increased flow of blood through it, and heat being brought, would raise the temperature; but this was found to rise during the continued contraction of the muscle, and of course the blood does not at that time flow into the muscle. 3d. The tissue in the act of contracting undergoes changes, and recompositions of its elements taking place, if any of its oxygen united with carbon or hydrogen, heat would be produced. The blood also brings oxygen from the lungs to the tissues, and it may unite with the carbon or hydrogen of the decomposing tissues; and, indeed, by its action may cause or assist in their decomposition. It may also be observed, that some of the decomposed substance of the body unburned in the tissue which yielded it may be transported to some place where it can be consumed, and produce heat in the act. In addition, it may be remarked, that every change which takes place in the body affects its temperature in some way. But as the action of the tissues is not as uniform as their healthful temperatures must be, their temperatures must not depend upon their activity alone. Provision has been made to supply the system with calorific food, which can also be stored up in the form of fat, serving the purpose of preserving heat while it remains, and being always at hand for use as a source of heat. In the body, therefore, there are three sources of hydrogen and carbon, which on the one side are calorifiers—viz., the decomposing tissues, the calorific food, and the fat which has been held in reserve. Oxygen is obtained from four sources—the three just mentioned, and the air breathed. The amount of heat produced in the system will therefore depend upon the amount of exercise, and food that may be used, upon the quantity of fat,—and especially upon the oxygen taken into the lungs. As the air when cold contains more oxygen in a given space than warm air, more of the effects of oxygen ought in cold weather to be exhibited. It is so; the colder the air, within reasonable bounds, the more heat will breathing it produce. The production of heat will also depend upon the natural constitution, upon the state of health, and upon mental influences. A cheerful disposition and warm heart greatly conduce to physical warmth. Let persons then have no fear of taking plenty of exercise in the pure, cold air. Neither let them fear that the night air is an insidious foe to the *warmly dressed* person; but let the whole atmosphere be a fountain from which to draw, night and day, the health-giving and health-producing oxygen.

What effect has muscular action upon the temperature of the muscles? Do the temperatures of the tissues depend on their activity?

Light—Electricity—Food.

Light.

359. *The especial influence of light* upon or in the system cannot be exhibited except in case of its direct influence upon the eye.

But it must not be concluded that light is unimportant in its influences. We see its genial influences upon the nutrition of the plant to be very great and conspicuous. It is also noticed in case of men, that sickness of any epidemic character is more fatal upon the shady side of the house than upon the side which receives the benefit of the sun's rays. Every room which is occupied should be so situated as to allow the sun to shine into it some portion of the twenty-four hours; health and comfort will be promoted thereby. The healthful and pleasant effect of some colors, and the unhealthful and unpleasant effect of others, will be shown in the chapter on the eye.

Electricity.

360. The character of electrical influences produced by, or exerted upon the body is yet so uncertain, that no further remark can be profitably made upon it, except to say, that, without doubt, the electrical states of the objects around have frequently no small effect upon man's physical ability.

Illus.—To many persons a change of weather will sometimes be indicated hours beforehand by pains of a peculiar character; indeed, a gouty person is a very good barometer.

Food.

"I tell you honestly what is the cause of the complicated madness of the human race: it is their gormandizing and stuffing, and stimulating the digestive organs to excess, thereby producing nervous disorder and irritation."—*Abernethy.*

This is one of the most important topics to which the attention of the student will be drawn; for, though it is exceedingly injurious for any person to be constantly thinking about the quality and quantity of his food and trying to observe its effects, yet he should

Can the influence of light be easily exhibited? Are its influences considerable? Which part of a house is most healthy, the shady, or that exposed to the sunlight? Are the influences of electricity now definitely known?

Dr. Moore's Remarks on Food.

well understand the general principles by which he should be governed in the selection of food, not so much for the preservation of health, as that he may keep all the tissues in such a condition that he can use and enjoy them to the highest degree and in the best manner. I propose here to introduce several extracts from the most excellent—indeed superlatively so—works of Dr. Moore.

"As before observed, the study of the stomach is the study of morality. By investigating the influence of food and drink on our minds, we soon discover the strongest motives for self-denial, and learn many a forcible lesson concerning the nature and extent of our responsibility. The results of mismanaging the stomach typify all the effects of our abandonment to any other propensity; for it is most evident that if we do not keep appetite under control, the right use of our reason is abolished, and we become more completely enslaved to our lusts than the most grovelling beast. The comfort and efficiency of intellect, nay, the moral perception, manliness, and virtue of the mind depend greatly on our use of aliment; and in the very means by which we sustain the strength of the body, or most directly disorder its functions, we at the same time either fortify or disable the brain, so that we shall be qualified to use our faculties with advantage, or else, amid the confusion of our sensations, be rendered incapable of rational attention. Who has not seen the bright dreams of his morning's philosophy clouded by the fumes of a tempting table, and the best resolves of calm thoughtfulness lost amid the sparklings of wine? Man has invented most of his dangers; he delights in exposing himself to artificial excitements, and he would rather run the risk of perdition than not try the force of temptation; for alas! since self-confidence first abased him, he has never believed that he could not conquer appetite according to his knowledge whenever he pleased, until he has found his will itself corrupted, and all his humanity helpless and undone. Animal instincts never conduct to such dangers; but the human mind, while it refines the sensations of the body by its own intensity, aggravates the evils amid which it riots, and by its greater capacity for pleasure twines the snare most cunningly around the soul, and by speculating in sensualities, raises a multitude of evil spirits, which at first appear in forms of delicious beauty, but as they weary his brain with their ceaseless presence, they gradually assume disgusting appearances, and as they become more and more hateful, he is more and more in earnest to dismiss them, while they only the more closely haunt and more thoroughly torment him. Reason has been placed by the only wise God in the midst of seductive influences, that by thus perceiving the slender tenure of her power, she may be forced to look above the body for motives to sustain her in dominion over appetite.

"The influence of diet on the moral and intellectual character of children has been extensively observed, because they present the best opportunity of witnessing the direct effects of bodily condition on temper, their feelings being undisguised. Of course, as their bodies are in the process of formation, their mental habits are also

What is Abernethy's opinion of overeating? What is the effect of investigating the influence of food? Why is there any connection between manliness of mind and aliment? Who is the cause of the dangers to which a man is exposed?

Influence of Food upon the exhibition of the Mental Powers.

forming; and it is of vast importance that this subject should be well understood. It is, however, unfortunately, but little regarded in general, and education is conducted more frequently as a plan by which the mind may be forced into any shape by fear, than as a matter the success of which will be proportioned to the care with which the body is treated and the faculties encouraged, according to physical fitness for mental enjoyment. The work of mental improvement should commence by improving the body. Let the soul be happy in its home, and it will soon expatiate amid ever varying ideas, and be ready to sympathize with all those who will lead it out to contemplate and enjoy the facts of creation and of history. This is the whole mystery of education. It has been proved, by comparisons among large numbers of children, that those brought up in poverty and privation, having of course a bad physical condition, are much more torpid in intellect and irritable in temper than children of the same age who have been better fed and cared for. Under the best and kindest teachers, the former cannot keep pace in mental advancement with the latter. This incapacity may be hereditary; for, alas! not the least among the numerous miseries of abject poverty is the physical deprivation which fastens on the souls of its children a tendency to mental aberration and degeneracy, by depraving the bodily constitution. We scarcely wonder that the wan and withered *young* mother, in whose breast starvation has dried up the fountain of nature's charity, should look with tearless but bloodshot eye upon her dead baby, and thank God for taking it away. This is no imagined possibility, but a bare, horrible, frequent fact. There are many such mothers, who, because labor is paid so grudgingly, witness no charm in the domestic circle; and many more who, after watching their infants through atrophies produced by their own hunger, have been rewarded for their affection and anxiety by the fierce ill-temper thus engendered in the boy or girl, whom neither weary wife nor cheerless husband has the wisdom or good feeling to soothe and manage; for, inured to the wretchedness of finding no pity from nominal Christians, they, too, seem to escape from the keener sensibilities of soul by indulgence in sensualities. Their moral nature has been starved by those whom God required to act as neighbors to them. Yet it is wonderful to see how the kindly affections generally triumph over these terrible evils of life, and how the noblest feelings flourish in the midst of the deepest poverty. Thanks be unto God, the poor have still a mighty faith in Him who feeds the sparrows, and in each other, too; so that they will, most of them, cheerfully divide the last small loaf with the needier, and then trust to Providence for the next meal.

"All our knowledge of blood and nerve, and of the purposes they are to fulfil in regard to the human soul in this world of wants and supplies, if it be worth any thing, proves to us one great truth—namely, that the dwelling of misery is not the home of virtue. Domestic comfort and privations are contradictions, and the wants of the body must be satisfied before the soul can find leisure for abstractions. It is a vain and aggravating mockery to preach, in words only, the doctrines of peace and loving-kindness where fathers and mothers and children cling together in rags and squalor and hunger. No doubt, among such are often found the most heroic examples of

How should education be conducted? With what should mental improvement commence? What effect does starvation diet have upon the tempers of young children? What is the character of the poor for generosity?

 Moderation in the use of Food the best Medicine.

Christian manliness and affection, but alas! there also dwells with misery every form of reckless viciousness. But what has that to do with your conduct, O man of comfortable morality? What self-denial have you practised for the benefit of your brother? It is true that the Gospel supplies aliment for the deathless spirit, and enables it to bear wisely, meekly, nay, even happily, the famishing of the body. We have witnessed its triumph in such a case, where disease actually caused death by starvation; but still the best harbingers of the Gospel are food and clothing, and all the visible evidences of sympathizing human heartiness. Be ye warmed, be ye clothed, be ye fed, are words, not practical faith; but providing the means for those who need them is true living godliness, which nowhere teaches men to take verbally even truth itself, much less wordy trash, as a substitute for bread. He who fed the multitude of famishing unbelievers in the desert of Arabia with daily showers of angels' food, will not have men convinced by miracles alone, but also with common mercy; and therefore the power and the goodness are seen together, as in Him who is our spiritual bread, and who taught us what He meant by loving our neighbor as ourselves. If, then, we would have the heart open to faith, we must appeal to it through charity and hope, nor think to prove our interest in the souls of men, without doing our very best to render the body a comfortable abode for the sublime and mysterious tenant."

"Moderation in the use of food is a far better remedy than medicine for an oppressed state of the circulation, whether arising from disease, or redundancy of supply. Fasting is the natural cure of repletion; and it is a curious circumstance, that abstinence is so frequently forced upon those savage tribes who are addicted to excess, such as the American Indians and New Zealanders. Their diseases are but few, except where they approach the confines of civilization, and in some measure adopt those habits which nature has rendered uncongenial to them. Among civilized nations, the use of purgatives is gradually taking the place of fasting. Hence the success of quackery in the aperient department among the English and Americans. We are an energetic people, and cannot be comfortable without abundant nourishment; but then, taking very refined food in large quantity, without sufficient intervals of abstinence, we find our brains and our bowels both miserably sluggish, and then the pill-box supplies a handy sort of remedy for ills that common sense should have prevented. 'The peristaltic persuaders' of the gourmand are as essential to his happiness as is his dinner; but not only do these gross livers need such helps: the exquisite poet must also resort to the apothecary to antidote the cook. Byron says, 'The thing that gives me the highest spirits is a dose of salts.' It diminished that congestion and irritability of his brain which his habits tended to keep up. He was at one period of his life epileptic; but he subdued the malady by extreme abstinence, frequently taking only vinegar and potatoes as his dinner. When he indulged in good living, and took stimulants, disorder of the brain returned in another form, and his temper became morose. It was then that a dose of salts cheered him. Brisk purgatives often relieve melancholy; and that most powerful one, hellebore, was the ancient specific for this disease, which generally arises from congestion of the liver and bowels causing an impure state of the

What is practical faith? What is the use of moderation in diet? What is a good effect of fasting? Are the diseases of savages numerous? What was the effect of high living upon Byron?

Foundations of Health and Happiness.

blood. The frequency of a condition approaching to this is the secret of the demand for universal medicines, in the shape of strong purgatives. Here is the evil: many good men, who read and think very much, and fancy they understand physiology, because they have read about the blood, prove their ignorance of it by taking little exercise, and dolefully mismanaging their stomachs. They forget that moderation in eating and drinking, as well as meditation, is a Christian duty, and that fresh air, cheerful society, and an occasional fast, would more effectually relieve the burdened *viscera* than a whole box of vegetable pills. Instances are not uncommon, even among the highly, but yet partially educated, in which some real malady has fixed upon the vitals, and those pills are swallowed in large quantities with manifest mischief. It is a matter of feeling, not of reasoning, with such persons. Their faith in the efficacy of the vaunted vegetables is grounded on ignorance, and confirmed by their sensations. Thus I have known a consumptive patient, of strong mind, obstinately persist in taking the pills, because they made him feel better, lighter, more cheerful, more happy. Of course, argument falls dead before such facts. Thus, in such forlorn cases, diarrhoea and purgatives hasten on the fatal issue; but then, by these means, the patients are kept just in that state which the highest degree of abstinence produces; their bodies waste and waste, but their souls are full of bright thoughts, as long as exertion is avoided. The habit of their minds becomes exalted by holy reading, it may be, and there is not blood enough in their veins to excite their passions, or to call their muscles into action. There is only just fuel enough to keep alive a clear flame, until the fire burns quite out. Such patients feel brighter and brighter to the last, and the pills, say they, are the cause of it all. These are taken again and again; exhaustion proceeds, but they go on to feel better, that is, lighter; the body is no impediment, except from weakness; so they continue taking the pills, and feeling better and better, until they die."

"The moral of this subject is comprised in a few words: our hopes of health and happiness must always deceive us, unless founded on obedience to the laws of God, which are those of a rational faith as regards things spiritual, and of true science as regards things natural."

361. As the tissues are constituted of a certain number of elements, it is evidently essential that food should be composed of the same elements.

It will, however, be shown by and by, why the digestive organs can operate best when reasonably distended. Therefore, it may not at times be prejudicial, but highly beneficial, to eat food which either does not contain the nutritious elements, or contains more than is needed. Those which are nutritious would, of course, serve to distend the organs; but in respect to using them for such

What do some very good men prove by their course of life? Upon what is faith in vaunted vegetables grounded? What is the moral of the subject? Why must the food contain or be composed of the same chemical elements as the tissues?

Elements which compose Food.

a purpose, there would be three questions: 1st. Are they as profitable or cheap as really waste substance? the answer to which would depend upon their cost and relish. 2d. Would they not be digested in larger quantity than necessary, and thus overcharge the blood-vessels? 3d. Would they not be detained in the digestive organs longer than waste and innutritious substance?

362. As the tissues are constituted of different elements, and as they are active in different degrees, the existence of different elements in different proportions would be required, and the food eaten should depend upon the tissue demanding it.

This is an exceedingly important idea. The man who is actively exercising his brain, does not require the same kind of food as the one who labors chiefly with his muscles; and it will be very unprofitable, mentally and physically, and pecuniarily, for them to live upon similar kinds of food. Farmers call pork and potatoes, and the like, food, and generally consider oysters, sardines and fish, as "trashy;" while students, the world over, desire to live upon these kinds of food, with eggs and fowls, &c. A broiled chicken is no "richer" food than a piece of fried pork, nor is food prepared from the brain of the calf any more so than a piece of lean veal. It may be asked, are not all the tissues—the fibrin and nervous, as well as the rest—formed from the albumen of the egg? Not from the albumen alone. The fibrin undoubtedly is. What is usually called albumen of the egg, and well enough in ordinary phrase, is something more than albumen, the white as well as the yolk (for they are very similar) being composed of phosphorus and calcareous substances in greater proportions than are necessary to form albumen. When, therefore, the albumen of the egg is spoken of, it is called ovalbumen or ealbumen. For convenience sake, in expressing my ideas, I am in the habit of classing the nutritious food as a species, and making of it several varieties, viz., three, named from the most conspicuous characterizing element—Phosphorized, Nitrogenized, and Calcareous—corresponding to and being those which nourish, or are by their components adapted to nourish, the three most conspicuous compound tissues—the nervous, muscular, and bony. The terms are not perfectly dis-

If nutritious food be used to distend the stomach, what three questions would arise? Upon what should the kind and quantity of food eaten depend? Do farmers and students need or equally relish the same kinds of food?

Character of different kinds of Food.

tinctive, for each of the three elements—phosphorus, nitrogen, and calcium—is found in each variety of nutritious food ; yet each is most conspicuous in the variety to which its name has been given. Each variety of food may be supposed to be usable for nourishing either tissue ; for if calcium predominate in the calcareous variety, yet it may, by the elimination of part of its calcium, be fit for forming muscular tissue ; but it is evident that any variety which does not contain a proper proportion of calcium, cannot form perfect bone. It may be thought that such a classification of the varieties of food should be made as would distinguish those which are adapted to form the secretory tissues and the secretions. This is doubtless to be done at some future day, but at present our knowledge is not sufficiently perfect to permit it to be done, however important it may be. In fact, the remarks which follow are to be considered rather as suggestive than an exhibition of demonstrated facts. The great value of such a classification and nomenclature of the varieties of food will consist in directing the attention of parents to the food of children—of the muscular laborer to the importance of not relying upon calorific food to give him strength—of the student to the fact that certain varieties of food are better than others for him. 1st. It has long been noticed, that the bones of infants and children cannot be developed without they are properly fed, viz., with calcareous food, e. g., milk, eggs, and the like. It is, however, often noticed that fat, arrowroot, and the like calorific kinds of food, are very beneficial to children (see Appendix), especially before they are able to take active exercise, or if they are feeble. The reason for this is dependent upon another principle. Young children have not the capacity of receiving much air, and, as rapid development prevents decomposition, they cannot produce heat corresponding in proportion to the escaping surface, which is relatively greater than that of a grown person : they must, therefore, depend chiefly upon their food for the production of heat, and, as that is small in amount, it must be carefully preserved by a thick layer of fat ; but it is very unfortunate for the bones, if, with fat-producing food, which increases the burden to be sustained, sufficient calcareous elements are not at the same time introduced. 2d. The man who labors with his muscles, in the winter requires calorific food in proportions according with his exposure ; but in the summer, calorific food will be required in only small quantity ; but at all times nitrogenized food must be used in proportions cor-

Are the terms used to distinguish the kinds of nutritious food perfect? Can we distinguish the varieties of food best adapted to secretory processes? To whom will a classification of the varieties of food be useful?

Food adapted to wants of the Nervous System.

responding with the muscular action. A dinner upon corn starch pudding or the like, would not sustain the labors of harvesting; while sour buttermilk from which the calorific fat has been removed, and in which the calorific sugar has been changed into acids, will be excellent. 3d. To sustain the labors of the student, phosphorized food seems necessary for the following reasons. *a.* The brain exhibits, upon decomposition, a proportion of phosphorus equal to one-twelfth, at least, of all its solid matter. *b.* Immediately after active mental labors, the excretions exhibit a large proportion of phosphates—e. g., Monday and Tuesday, in case of clergymen; and, at court time, in case of lawyers. Persons troubled with phosphatic deposits, are most likely to be so after unusual intellectual efforts. Moore remarks that “the condition of blood which precedes gout is so constantly associated with irascibility, that John Hunter says gout and anger are almost synonymous in some persons.” Though in this case the state of the blood may have much to do with causing the irascibility, it is probable that this, by exciting the brain and causing its rapid decomposition, is the cause of phosphates being furnished to the blood which it usually deposits in the gouty joints. *c.* The common experience of students is, that they are fond of, and profited by, different food from what they most relished when daily and arduously engaged in labor of a chiefly muscular character. Many lawyers have told me that they were particularly fond of sardines at “court times” only—most often, also, they witness to their greater appetites at such than usual times—though sometimes they have told me that their cases caused too much excitement for them to wish for food then; but, after they returned home, they were correspondingly exhausted and hungry. Students also complain of having much more appetite during term than vacation time; and to think that they do not have enough to eat, when the probability is that they eat too much in quantity, but of improper quality; and the nervous system, not being perfectly nourished, gives signs of its necessities, before the time of another repast, by causing the sensation of appetite.* In my own experience, I have

* In cool weather, many young ladies dress so thinly that but little heat is preserved, and there is almost a constant call for food to produce it. They wish therefore, on one hand, to eat almost constantly, and on the other, to have the temperature of their dwellings higher than is proper. Again, some keep their room (or clothing?) so warm that there is not a sufficient demand for calorific food, to produce a healthy appetite.

Why is sour buttermilk good as food in hot weather? What is the first reasons for thinking phosphorized food profitable to the student? What is the effect of intellectual activity upon the existence of phosphates in the blood?

Food must be composed of Organic Elements.

constantly observed the value of the kinds of food specified above. I have no hesitation and feel no inconvenience in lecturing 6, 7, or even 8 hours during the day and evening, from the beginning to the end of the week, as my business and custom is, if I can have a proper supply of the right kinds of food; but, if I do not, memory soon becomes treacherous, sharp pains and exhaustion are felt in my head, and, if the mental labor is continued, symptoms of paralysis will be felt—all of which evils can at once and always be removed by one or two hearty repasts of oysters, sardines, soft eggs, or fish. These kinds of food may not be equally serviceable to other persons; if they are, it is not certain that all of them contain phosphorus in remarkable quantity. Eggs most surely do; and a remarkable case was to-day mentioned to me in conversation with a professional friend, of one of the most valued and industrious students in the city who makes eggs his chief diet in periods of arduous labor.* If these kinds of food contain notable quantities of phosphorus, and are serviceable, it is not certain that their chief value is dependent on the phosphorus. This, however, is probably the case.

363. *Food must not only be composed of proper chemical elements, but these must be compounded into proper organic elements.*

Phosphorus, important as it is, by itself alone would prove a violent poison; it must not only be compounded with oxygen and produce phosphoric acid, but this must also be united with other substances. Whether any merely chemical compound elements can be used in the human body, is uncertain as yet. Some suppose that compounds of iron are absorbed into the blood, and there combined with its organic elements, or used in the formation of them. It is probable that the chemical compounds of lime

* The qualities of egg in respect to phosphorus, will vary as much as in respect to other components. The farmer thinks that lime must be furnished to the chicken, because the shell is so conspicuous; but the honest-hearted hen insists on forming the contents of the egg first; but the difference in the taste caused by different eggs, is based on a reality, as is the color of the yolk. If the fowl have plenty to eat of its natural diet, eggs are produced not only in abundance, but of a rich quality. The most natural food for fowls is bugs and worms, the phosphorized character of some of which is evident enough. If these cannot be had, fish is not only adapted to their palate, but to the profit of the keeper. Lean meat is known to be one of the best kinds of food for fowls, while grains are to a great degree waste, containing more starch and oil than the warmly-clothed fowl needs.

What kinds of food have been specified? Is it positively certain that the adapt-
edness of these kinds of food is universal or dependent on phosphorus? Is it suffi-
cient to eat the chemical elements uncombined?

Kinds of Food distinguished.

which are fed to and eaten by fowls do, to a greater or less degree, pass into their blood, and at last go to form the egg-shell. It may be, however, that such things are only useful in triturating the food in the gizzard, and that all the lime of the shell is obtained from organic elements eaten as food. There is scarcely a doubt that common salt passes into, and becomes part of, the blood, as a compound chemical element. Yet, as a rule, the food of animals must be prepared in the form of organic elements by plants. Food should, therefore, be composed of these elements in such proportions as the action of the tissues or their requirements in respect to heat indicate. There is no difficulty in distinguishing the elements adapted to nourish the tissues from those which are useful in respect to heat. Fat, starch, saccharine substance, including gums and gelatin, are calorific. Alcoholics come under this head; for, though in all ordinary cases alcoholics cool the system in cold weather and heat it in summer, there are states of the health when the use of alcohol is followed by the rapid production of fat, and as the elements composing alcohol are oxygen, hydrogen, and carbon, there is no good reason to doubt that the fat is formed from alcohol. But under all ordinary circumstances the use of alcohol does not produce heat; it so acts on the nervous system as to cause sensations of heat, or prevent the production of sensations of cold, and thus cheats its victim. The abundance of acids which nature has provided in the southern climes, the great use of them in summer, the coolness which follows their use in hot weather, and the effect of a very free use of them in diminishing the quantity of fat deposited in the system, lead to the belief that acids are useful either in preventing the production of heat, or neutralizing it when produced. They are, therefore, counted as cooling parts of the food. For a person to attempt to reduce the quantity of his fat by the use of acids is not wise, as the general health will be injured. Let him rather abstain from the use of calorific food, and take plenty of exercise in the open air. The nutritious food cannot be distinguished as accurately by organic elementary characteristics as the calorific can be, for, though chiefly composed of albumen, fibrin, and casein, yet with these are combined or mixed various chemical elements in a manner which has not yet been ascertained. The contents of an egg-shell are loosely called albumen, but there is something more. Of one thing we may be sure—viz., that the three mentioned elements are nutriment. The waste

Does lime, if eaten as lime, or in the form of plaster or oyster-shells, &c., go to form the egg-shell? As a rule, how is the food of animals formed? What is said of alcoholics? What is said of acids?

 Uses of Oxygen.

portions of food include the cellulose and lignine of vegetables. Whatever portion of food has not been properly prepared, or is used in greater quantity than the system requires, is, properly speaking, to be added to the really waste food. A table of different kinds of food is given in the Appendix. Many of the organic elements require to be prepared for the use of animals. This is called the process of cooking. This has a double object—to render the food more wholesome, and to improve its relish. For this purpose several kinds of organic elements must sometimes be mixed, and flavored with chemical elements, useful or waste, and then, perhaps, exposed to the action of heat. The advantages of any such preparation will be better seen after the organs adapted to receive and act on the food in the body, and their mode of action, are described.

Air.

365. *The utility of the air* is dependent on the quantity of oxygen it contains, and its freedom from every thing but that, nitrogen, and a proper portion of water.

Water, however, is not usually estimated as a part of the air; yet it always exists, and is a *sine qua non* as a part of the substance breathed.

366. *The oxygen* is mixed with the nitrogen of the air, as it is with the water which the fish breathes.

The analogy will be more perfect, then, if we say that man breathes the nitrogen to obtain the oxygen mixed with it; or it may be said that the nitrogen dilutes the oxygen for men to breathe, as water dilutes it for the fish.

367. The uses of oxygen in the system are two and perhaps threefold; it unites itself to the blood, as it is supposed, to the red corpuscles, the effect being to shrivel them somewhat and render them slightly biconcave; when the reflexion of light from them will be such as to give them a

What is the utility of cooking food? Upon what is the utility of air dependent? Is water a necessary adjunct to the air? What is the number of uses to which oxygen can be applied in the system?

bright red appearance. Thus the corpuscles become carriers of the oxygen.

Some suppose that the oxygen unites with the iron of the corpuscles, but this would not account for the color, which has not been satisfactorily accounted for, until recently. It may be that the oxygen perfects the nourishment of the corpuscle or its contents, for it is not known with what part of the corpuscle or how the union is, and it may be that oxygen unites with other parts of the blood.

368. The oxygen borne by the corpuscles into the minute capillaries, exerts its strong attractions upon the unstable tissues, and assists in, or alone causes, their decomposition, and then unites with these elements, producing heat, water, and carbonic acid, which combine with the components of the corpuscles,—as some think with its iron,—causing them to become plump and biconvex, when the reflection of light causes them to appear dark. They carry the carbonic acid to the air, and it escapes from the blood at the inner surface of the lungs, and is expired with the breath.

369. *The air is more dense* in cold than in hot weather, and of course contains a greater amount of oxygen in a given cubical space than when it is warm, and the cold air expanded by the heat of the chest acts more energetically than if warm air be inspired.

Illus.—When the air is blown against the burning coals, its oxygen unites more actively with the carbon. When the air is very much rarified by heat, it is difficult to prevent a slight feeling of suffocation.

Inf.—It follows as a very important conclusion that cold air will produce more heat than warm, as ought to be the case; also, that when cold air is breathed, more carbonic acid will in a given time be removed from the system than when the air is warm. In cold

Is it certain whether or not the oxygen unites with the iron of the blood? What effect on the tissues does oxygen have? What effect does carbonic acid have upon the corpuscles? What is the difference between cold and warm air?

Qualities of Air—Water.

weather, therefore, we ought to breathe cool air to produce heat and clarify the blood, and clothe ourselves warmly to preserve the heat produced.

370. *When air is warmer than that which surrounds it, it ascends.*

Inf. The air breathed from the lungs into cool air, rises rapidly and is not again received; to preserve the air pure, it should be kept cool. It should never in winter be allowed to rise above 65° in an apartment for healthy people, properly clothed.

371. *Air which is cold, contains less moisture than warm air.*

Inf. It is not, therefore, as damp towards morning as it is in the middle of the day. There is no danger, therefore, of breathing cool air because it is extraordinarily damp.

372. *The air of a close room in which a person breathes, is soon saturated with moisture.*

Inf.—A room for being closed, is no drier than if ventilated.

It may be asked, Is not the damp air colder apparently than dry air of the same temperature? Yes—because the water receives heat more readily than air. When, therefore, the air is damp, so much more pains must be taken to dress warmly, or the system will suffer from loss of heat. It is for want of this precaution that persons take cold, and attribute to the weather what should be imputed to themselves. If the system is in ordinary health, it will always be improved by receiving into its lungs the pure, cool air of the atmosphere. If the system, from infancy, from ill health, or from old age, be incapable of producing as much heat as is necessary to warm the inhaled air, it must be warmed, of course.

Water.

373. *Water is a necessary element of most of the tissues. As a solvent, it assists in the absorption of nutritious and excrementitious substance. By moistening the tissues, it*

What becomes of exhaled air? Why does damp air seem colder than dry? What is the use of water? What kind of water is best? How is water rendered poisonous?

allows them without friction to glide over each other. It readily communicates and receives heat.

374. *Pure soft water* is the only kind of water which it is perfectly proper to drink.

Water is frequently rendered poisonous by passing through lead pipes. The water which is obtained from springs is frequently loaded with impurities, especially compounds of calcium, as in the ordinary hard water. Rain-water is the purest and best of water which can be obtained. Rendered cool by any means, it is quite as palatable to the accustomed palate as hard water, which is productive of many diseases.

Review.

Thus, having hastily presented a view of the simple and compound chemical and organical elements which compose the tissues and humors of the human body, and shown what is meant by systems, as well as exhibited the properties of animal tissues to be sixfold—viz., nutrition, development, reproduction, secretion, sensibility, and contractility, all of which require that absorption should be free and the temperatures of parts healthy, and all of which depend upon the reception and preparation of food, and upon imbibition of water, and the respiration of air—it is now time to consider the individual or special organs which are constructed from the systems in accordance with the use or action which they are required to fulfil. And as each organ or part is described, we shall see the necessity for employing peculiar tissues, with peculiar properties, in each case. With the anatomical description of each organ, or even part of an organ, its use, or the why and wherefore of its being made as it is, must be immediately presented, as well the means to be employed for developing the properties required to the highest degree and in the best manner. Thus, and thus only, can the branches now before the student be easily understood, remembered, and practically applied.

PART III.

SPECIAL ANATOMY, PHYSIOLOGY, AND HYGIENE.

"There is something higher, then, than even the study of laws, which may be regarded as being themselves but a higher order of facts. There are three degrees, and the science that would tarry in the second must be pronounced spurious, as well as that trivial knowledge which finds its satisfaction in the first. There are facts, laws, principles. By the latter are meant those *thoughts* of the universal mind, of which the second may be regarded as the *words*, and the first the *letters* through which they are articulated. There is an intense interest in the question—*What* is it?—its class, its order, its outward description, and hence its scientific name? There is a higher interest in the question—*How* is it?—its law, its cause, its effect, its outward energizing life? There is a still higher interest in the inquiry—*Why* is it?—why is it so in itself? *Why* is it so in its relations to other things? *Why* is it so in its relations to the Great Whole, of which, however minute, it forms a necessary part? Above all, *Why* is that Great Whole itself; whose ground, end, or destiny is the ultimate inquiry which makes the real value of every lower question?"—RAYMOND.

BOOK I.

APPARATUS OF RELATION.

DIVISION I.—MOTOR APPARATUS.

CHAPTER I.—SKELETON.

ANALYSIS.

Distinction between artificial and natural skeleton. The last embraces bones, cartilages, synovial membranes and ligaments—General characteristics of bones—Names of their parts—Classification of Joints and Ligaments—Division of skeleton into protective, speaking, handling, and locomotive skeletons—Division of protective into head and spinal column—Division of head into cranial and facial bones—Description of cranial bones—Occipital, Sphenoid, Ethmoid, Frontal, Temporal, and Parietal—Description of facial bones—Superior Maxillary, Malar, Nasal, Ossa Unguis, Turbinated, Vomer, and Inferior Maxillary—Division of spinal column into Cervical, Dorsal, Lumbar, Sacral, and Coccygeal regions—Cause of deformities of the column—The Chest—Ribs—Costal cartilages—Sternum—Latitude of motion of the ribs the important object—Causes of deformity of chest—Thoracic extremities—Clavicle—Scapula—causes of its prominence—Humerus—Radius and Ulna—Hand—Os Innominatum—Pelvis—Femur—Lower leg—Foot—Review.

General Remarks.

375. *The complete assemblage or system of bones* in an animal is called a skeleton. If they are fastened together by wires, they form an artificial skeleton. When they are fastened by their proper cartilages and ligaments, they, with those, form a natural skeleton.

A consideration of the natural skeleton embraces, therefore, the bones, cartilages, joints, synovial membranes, and articular ligaments. There are several things to be said which are applicable to the whole skeleton, before we proceed to consider its individual parts; explanatory remarks upon the bones, joints, ligaments, their classification, &c., which may be closely observed or omitted, as is thought desirable.

The *nomenclature* of the bones is very imperfect. Names have been given to them, 1st, from their position; 2d, from a real or fancied resemblance to some object; 3d, from their size; 4th, from peculiarity of conformation; 5th, from the name of the author who has described them.

Color.—The color of bones varies, from a yellowish to a decided white, as may be seen in any animal.

The *size* of bones varies exceedingly, from that of a pin's head to that of the femur and hip.

The *form* of bones, together with their size, has caused them to be classed as long, short, and broad. A long bone is divisible into a shaft and extremities. They serve the purposes of levers, and are, of course, found in the extremities. The ribs are also of this class. The short bones are grouped together, to form any part where great solidity with slight mobility is required, as in the wrist, ankle, and spinal column. The broad bones are adapted to form the sides of cavities.

The *surfaces* of bones are so irregular, and present so many things to be noticed, that they must be very accurately divided. Thus the long bones, being prismatic, exhibit three faces and borders for consideration; the broad or flat, two faces, external and internal, and a circumference; the short, six faces, and all of them present angles. All these are named sometimes from their situation—superior, inferior, &c.; sometimes from what they contribute to form—as the orbital face, &c.; sometimes from relation to other parts—cerebral surface of the cranium, &c. The borders are divided by three parallel lines, the middle called the interstice, the other two, the lips.

The *eminences* of bony surfaces were by the ancients divided into apophyses and epophyses. This distinction was, however, founded upon limited observation. A better distinction is, into articular and non-articular.

What is the difference between a natural and artificial skeleton? What does a natural skeleton include?

The teacher may ask or omit the questions upon the descriptions in small type; it is suggested that it will be sufficient for the student to read the descriptions.

Articular eminences are called *denticulations* when they present a notched and jagged appearance—fig. 9. They contribute to form immovable joints; *heads* when they present a portion of a sphere, joined to the body by a contracted portion, called the *neck*; *condyles* when they appear like an elongated head, or like a portion of an egg longitudinally divided.

The *non-articular* eminences are mostly designed for the attachment of muscles. They are denominated—1st, *prominences* when slightly elevated, smooth, and extended equally in all directions; 2d, *mamillary processes* when they resemble papillæ; 3d, *tuberosities* when they are of larger size, roundish, and uneven; 4th, *spines* or *spinous processes* when they are more pointed; 5th, *lines* when their length much exceeds their breadth; when the lines are rough, or exhibit asperities, they are called *linæ asperæ*; 6th, *crests* when they are elevated, with a sharp edge; 7th, *apophyses* or *processes* has been retained for those eminences which seem to be small bones added to others, and specific names designating such have been added, from various reasons, as, from resemblance; these are—the *clinoid*, *pterygoid*, *mastoid*, *zygomatic*, *styloid*, *coronoid*, *odontoid*, *coracoid*, *malleolar*; from the parts they contribute to form—the *orbital*, *malar*, *olecranon*, &c.; from their direction—the *ascending*, *descending*, &c.; from their uses—the *trochanters minor*, *major*, &c. No part of anatomical language is more faulty than the names of eminences, the same names being applied to parts very dissimilar. "The size of these eminences corresponds to the strength of the muscles acting upon them, as seen by comparing a male and female skeleton, or those of a sedentary and athletic person. This has given rise to the idea that muscular action produced the eminences. This notion is easily refuted by facts proving that osseous eminences enter into the original plan of organization, and would have existed though the muscles had not acted. Twice have I dissected the arms, paralyzed from convulsions in infancy, of individuals. The affected limb was hardly as large as that of a child eight years old, yet the smallest as well as the largest prominences were distinctly marked."—*Cruveilhier*.

The *cavities* formed by the surface are divided into articular and non-articular. The *articular* are denominated—1st, *cotylloid*, as the socket in the hip bones; 2d, *glenoid*, as the shoulder socket; 3d, *alveoli*, as the sockets for the teeth. *Non-articular* cavities are called—1st, *fossæ* when widely excavated; 2d, *sinuses* when the entrance is narrow; 3d, *cancelli* and improperly *cells* when the cavities are small but numerous; 4th, *channels* or *gutters* when a semi-cylindrical, long, open canal exists; 5th, *grooves* when channels are lined with cartilage. A groove is called a *trochlea* or *pulley* if a tendon is changed in its direction by its means; 6th, *furrows* when the channel is very shallow; 7th, *notches* when the appearance is that of a notch.

Perforations of the bone, or notches of different bones being so situated as to give an appearance of perforations, are called *foramina* or holes, and distinguished, 1st, when irregular, as *foramen lacerum*; 2d, when very small and irregular, as an *hiatus*; 3d, when long and narrow, as a *fissure*; 4th, when extending some way through the substance of the bone, as a *conduit* or *canal*. If they lodge vessels for nourishing the bones, they are distinguished as nutritious canals, though they are

What is said of the names of bones? Color? Size? Form? Surfaces? How are eminences classed? How many and what kinds of articular eminences? What are prominences? Mamillary processes? Tuberosities? Spines? Lines? Crests? Apo-

only large Haversian canals. They are divided into three kinds: 1st. Those which belong exclusively to the shaft of the long bones, and some broad ones. Each one soon divides into two branches, one the ascending, the other the descending. In each bone the minute anatomist points out the situation, direction, and course of each of these very particularly. 2d. Those which are found near the head of the long and the borders of the broad bones. Bichat has counted 140 in the lower end of the thigh bone, 20 in a vertebra, and 50 in the heel bone. They sometimes pass entirely through the bone, and sometimes communicate with the cancelli. 3d. Those which are microscopic—viz., those Haversian canals which open from the surface. When the periosteum is torn from the bone, the vessels entering there being severed, bleed, and show their position by minute dots of blood. The *uses of the cavities* are, 1st, to receive or protect organs; 2d, for surfaces of attachment; 3d, for the transmission of organs, vessels, nerves, &c.; 4th, to increase surface in a small cubical space; 5th, for the easy movement of tendons, and to give them a new direction; 6th, for the nutrition of bones.

In *describing bones*, 1st, the surface should be so divided as to present but few objects at a time; 2d, when they are divided, care should be taken to proceed from one side to the opposite; 3d, an invariable and regular order of the regions must be followed; 4th, in symmetrical bones, first the objects in the median line, and second the lateral parts, should be described.

Composition of Bones.—In Part II. it was shown, 1st, that the external surface of bones is covered with fibrous membrane called periosteum; 2d, that the substance of the bone is composed of fibrous tissue and earthy compounds; 3d, that the long bones after the period of childhood exhibit a central medullary canal, which grows larger with advancing age; 4th, that about the canal, and especially towards the ends of the long, in the short, and between the two laminae of flat bones, cancelli exist, which approach nearer to the surface with maturing years, and in old age leave a very thin shell of solid bone at the surface. Though, by the deposit of earthy substance, any portion of bone in an old person is denser than in youth, as a whole, it is lighter; 5th, that all the medullary cancelli and canals are lined with fibrous membrane which is lined by secretory membrane, the whole of which is called the medullary membrane, which secretes the marrow or medulla. The cancelli and canal being more extensive in old persons, there is in their bones more marrow, which prevents the jar that, through their more dense bones and less elastic cartilages, would be produced. The exhaustion of the marrow in debilitated persons renders them exceedingly sensitive to causes of jars; 6th, that the microscope reveals Haversian canals, canaliculi, and lacunae; 7th, that in the membranes covering and lining the bones, nerves exist. They must be nerves of sensation, as nerves of motion would have no office. They are so constituted that in health no sensation is produced through them, but as soon as disease attacks the bone they become very sensitive, that the person may be compelled to allow his limb to remain quiet and recover. In case of fracture it is very unfortunate if the nerves do not cause pain, which is better than any "splint" for securing quiet. If pain does not occur, the individual is very liable to have a bad limb, notwithstanding the care of the most skilful surgeon, whose

phases? How are osseous cavities classed? What cavities are called cotyloid? Glenoid? Alveolar? Fossae? Sinuses? Cancelli? Channels? Grooves? Trochlae? Furrows? Notches? What is a foramen lacrum? Hiatus? Fissure? Conduit or canal?

first anxiety, many times, will be to produce pain; 8th, that in the fibrous membranes of bones, arteries, capillaries, and veins are numerous. Lymphatics have not, as yet, been detected; 9th, that the organic element of bones is gelatin, combined, how is not yet understood, with chiefly phosphate and carbonate of lime. The following table, from Berzelius, shows the constitution in detail:—

ANIMAL MATTER REDUCIBLE TO GELATIN BY BOILING,	32.17
ANIMAL MATTER INSOLUBLE,	1.13
PHOSPHATE OF LIME,	51.04
CARBONATE OF LIME,	11.30
FLUATE OF LIME, (?)	2.0
PHOSPHATE OF MAGNESIA,	1.16
SODA, AND CHLORIDE OF SODIUM,	1.20

The *situation* of the bones is internal in man; in some animals the skeleton is external. The situation of particular bones is yet to be described, as are their relations.

The *connections* of the bones are the joints, a description of which comprehends cartilages, synovial membranes, and ligaments. Several remarks common to each class of parts may properly be made.

Articular cartilages are divisible into, 1st, *Synarthrodial*, which exists between bones denticulated together, or which form immovable joints. This cartilage results from the ossification of the bone not having proceeded into it; 2d, *Diarthrodial*, where the cartilage adheres to the bone upon one side, but is perfectly free upon the other, as at the shoulder-joint; 3d, *Interarticular*, where an extra cartilage free upon both sides is found in the joint between the cartilages covering the ends of the bones,

as in Fig. 92, representing one in the joint of the lower jaw with the upper. They are usually thick at their circumference and thin in the centre, or biconcave, and hence called a *meniscus*. In the above figure the upper surface of the cartilage is convex, to fit the concavity about it. They serve the same purpose as friction wheels in machinery, and also deaden jars; 4th, *Amphiarthrodial*, where the cartilage adheres to the bone upon each side, but by its own flexibility, and pliability, and elasticity, allows some motion. Attention should also be drawn to the fact, that the sockets of joints are many times deepened by a circle of fibres round the edge. The surface of bone covered with cartilago depends upon the extent of motion required.

Synovial membranes are closed sacs, the outside of which adhere to the cartilages of the joint and the parts surrounding it,

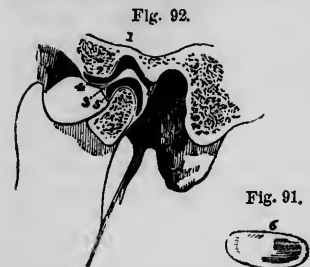


Fig. 92.—Section of the joint of the lower jaw. 3, Cartilage dividing the joint into two parts. 4, The upper, 5, the lower cavity, both lined with synovial membrane. 1, The socket in the bone which receives the upper surface of the cartilage. 7, A portion of the lower jaw, which moves upon the under surface of the cartilage. 6, The cartilage taken out of the joint.

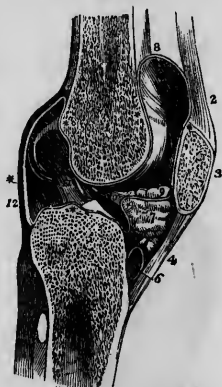
and are moistened on their inner surfaces with synovia, which they themselves secrete.

How should unpainful broken bones be treated? What is the constitution of bones, according to Berzelius? Who is he? Situation of bones in man? Connections of bones are called what? What joints are called anarthrodial? Diarthrodial?

They are, therefore, secreting membranes, compounded also in part of fibrous membrane. At first they cover the entire cartilage very conspicuously, but after the joint has been used some time they become so thin upon the contactile portions of cartilage, that it is doubtful whether they exist there at all. At certain joints there is a cushion of fat upon one side, pushing the membrane into the joint, as in Fig. 93.

Fig. 93 represents a section of the knee joint. 1, Lower portion of femur or thigh bone. 5, Upper part of tibia or shin bone. 3, Patella, rotula or kneecap. 2, Tendon of rectus muscle. 4, Tendon connecting the patella with tibia. * Denotes the synovial membrane or capsule. 6 Indicates another capsule, or more properly a bursa between the tendon and tibia. 9, One of the ligamenta alaria. 10, Mucous ligament. 11, Anterior crucial ligament. 12, Posterior ligament.

Fig. 93.



This capsule, as the membrane is called, renders the joint air-tight, and keeps its surfaces in close contact, except when much force is exerted, when the parts separate with a crack (the cracking of the joints.) The fat seems to be for the purpose of filling all the spaces about the joint in case of any motions. The synovial membrane sometimes exists in folds at certain parts of the joint, thus increasing the extent of surface for secreting synovia.

Articular ligaments are of two kinds, fascicular and capsular. *Fascicular* ligaments are those composed of fibres in the form of bands. The fibres are either yellow or white. The *capsular* are the names of those ligaments which completely surround a joint; they are merely continuous fascicular ligaments.

Joints are divided into the immovable, movable, and mixed, which classes are technically designated *synarthrosis*, *diarthrosis*, and *amphiarthrosis*. *Synarthrosis*; the characteristics of this joint are immobility, and a joining of the bones without any intervening synovial cavity; its varieties are, 1st, *Suture*, which is subdivided into *a, dentata*, where the bones are united by long processes and deep indentations; *b, serrata*, when the processes are shorter, and like saw-teeth; *c, limbosa*, where, with dentation, the margin of the bone is bevelled; *d, notha*, or false suture, when the juxtaposed surfaces are merely rough; of this there are two kinds, one *squamous*, when the bevelled edge of one overlaps that of another, and one *harmonia*, where there is simple apposition. The cartilage of sutures has a tendency to become ossified, when they are obliterated. After fifty, some of those of the skull are almost always in this condition. 2d. *Schindyllosis* is where the edge of a bone is received into a cleft or groove in or between others. 3d. *Gomphosis*, where there are such sockets as receive the teeth.

Diarthrosis; mobility, with synovial cavities, is the distinguishing characteristic of this class of joints. Bichat divided this class into the gliding, limited opposition,

Describe fig. 93. What causes the cracking of the joints? What is the use of fat about the joints? What are fascicular ligaments? Capsular? What kinds of suture are there? What kind of joint is Schindyllosis? Gomphosis?

circumduction, and rotation; the technical terms corresponding are, 1st, *Arthrodia*. In this case the surfaces in contact are plane or slightly concave and convex, and the motion gliding, limited only by ligaments or some process of the bones; 2d, *Ginglimus* or hinge-joints, admitting only flexion and extension; 3d, *Enarthrosis* or ball and socket, permitting motion in every direction; 4th, *Rotatorius*, the conspicuous characters of which are a pivot and ring, the last generally formed partly of bone and partly of ligament.

The *development of bone* is marked by three stages; 1st, the place of the bone is occupied by a jelly-like or mucous substance, exceedingly delicate; 2d, gradually it is changed into cartilage, yielding chondrin, how is not known; 3d, at sometimes one,

Fig. 94.



and sometimes several points in the cartilage, called points of ossification, specks of earthy matter are at first deposited, and the substance of the cartilage at the same place becomes fibrous, yielding gelatin. The process extends till the whole bone is produced. Ossification does not begin at the same time in all bones, nor progress with equal rapidity in all where it has begun. The bones of the ear being earliest required for perfect use, are earliest perfected in structure. The ribs being needed in breathing, are ossified early, and so with other bones. This is another instance showing that structure is subservient to use, and that the idea of use should, in a natural order of thought, precede that of structure. In infancy the walls of the cranium should, for many reasons, be yielding, and not perfectly ossified. Hence we find, for a long time, that a portion of the top of the cranium remains unossified; see fig. 94, where 1 represents the posterior, 2 the middle, and

3 the anterior fontanelles. At 4, ossification is not completed; 5, 5, are over the suture formed at those parts. Though ossification has not taken place at 3, the change from cartilage to fibrous tissue has occurred, and at 3 there is not cartilage, therefore, but a membrane.

The *uses of the skeleton*, and how its *wants* should be provided, will appear in the descriptions to follow.

376. *The natural skeleton* is divisible into four classes of parts useful for 1st, protection; 2d, speaking; 3d, handling; and 4th, locomotion.

Each class assists, and to a certain extent might be included in,

What is arthrodia? Ginglimus? Enarthrosis? Rotatorius? How many stages in the formation of bone? Describe fig. 94. What exists at 3? Into what classes of parts is the natural skeleton divisible?

Fig. 95.

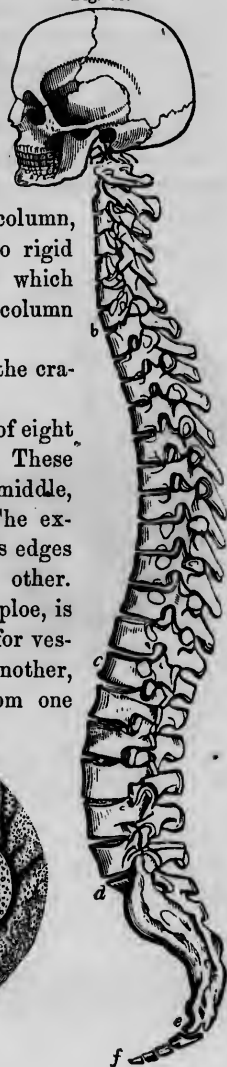
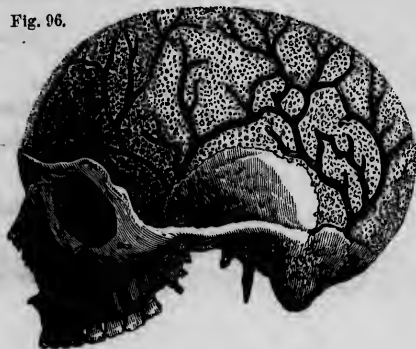
the rest, but is named from its most conspicuous office. The old division of the skeleton into head and trunk was, and is very unphilosophical and improper; there is no reason for it, and it is no longer to be tolerated; it was hardly worthy of the dark ages. See *Knox's Anatomy*.

377. The *protective* parts of the skeleton embrace the skull and spinal column, and are correspondingly divided into rigid and elastic protections; see fig. 95, which presents a side view of the spinal column supporting the skull.

378. The *skull* is divisible into the cranium, and the facial bones.

379. The *cranium* is constructed of eight bones, one cuboidal and seven flat. These are all constructed of an external, middle, and internal layers, called tables. The external is tough and called fibrous; its edges are notched and dovetail into each other. The middle, denominated also the diploe, is wrought into cancelli and channels for vessels which extend from one bone to another, as if the diploe were continuous from one

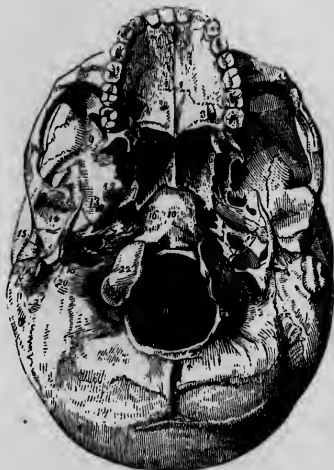
Fig. 96.



bone to another; see fig. 96, where the fibrous table is represented as removed from the sides of the cranium, exposing the diploe; the temporal bone contains but a very thin stratum of diploe. The inner table is brittle, and called vitreous or glassy; it is not, however, as brittle as glass. Its joints are those of harmonia.

380. The *cranium* presents an arched form in all exposed directions; beneath, it is somewhat flattened, and its surface very irregular; see fig. 97, which represents the base of the skull. It also presents for consideration an external and in-

Fig. 97.



ternal surface. Its external surface, except at its base, is generally smooth, exhibiting prominences and ridges where the greatest strength is required; it is also marked by the sutures. The internal surface is smoother than the external. It also exhibits ridges and prominences, but is as remarkable for its concavities as the external for its convexities; indeed, there is a general correspondence between them. It is also deeply grooved for the situation

of large vessels. The bones of the cranium are covered with fibrous membrane called here the pericranium. They are lined with a thick membrane called specifically *dura mater*.

What does the protective framework embrace? How is the skull divided? How many bones compose the cranium? Describe their general structure. Why is not the outer table of the temporal bone removed? Describe the form and general character of the cranial surfaces.

Fig. 98 represents the external, and fig. 99 the internal, surfaces of a cranial bone called the *occipital*. Its name is derived from its situation. It is situated at the lower middle and back part of the cranium—the hole 5 or 7 corresponding to that represented by 11, the black, in 97. It is remarkable, 1st, on account of the hole 5, called foramen magnum, through which the brain and spinal cord connect; it is of course directly over the spinal canal; 2d, for the condyles 6, 6, by which the head is articulated to the upper bone of the spinal column; 3d, 1, 2, 3, are the superior and inferior occipital ridges and protuberances so easily felt at the back of the head. The internal surface is remarkable, 1st, for the concavities or fossæ, 1, 2, which receive the back part of the cerebrum and cerebellum; 2d, for the crucial ridges 5, 5, 3, 4, which at 6 form

Figs. 98 and 99.

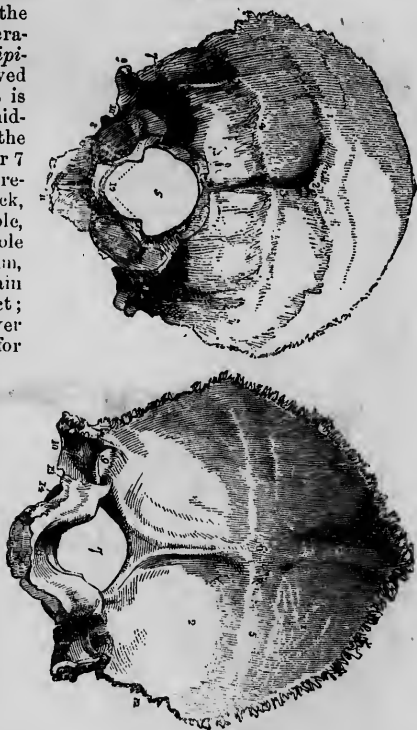


Fig. 97.—The external or basilar surface of the base of the skull. 1, 1. The hard palate. The figures are placed upon the palate processes of the superior maxillary bones. 2. The incisive, or anterior palatine foramen. 3. The palate process of the palate bone. The large opening near the figure is the posterior palatine foramen. 4. The palate spine; the curved line upon which the number rests, is the transverse ridge. 5. The vomer, dividing the openings of the posterior nares. 6. The internal pterygoid plate. 7. The scaphoid fossa. 8. The external pterygoid plate. The interval between 6 and 8 (left side of the figure,) is the pterygoid fossa. 9. The zygomatic fossa. 10. The basilar process of the occipital bone. 11. The foramen magnum. 12. The foramen ovale. 13. The foramen spinosum. 14. The glenoid fossa. 15. The meatus auditorius externus. 16. The foramen lacerum basis cranii. 17. The carotid foramen of the left side. 18. The foramen lacerum posterius, or jugular foramen. 19. The styloid process. 20. The stylo-mastoid foramen. 21. The mastoid process. 22. One of the condyles of the occipital bone. 23. The posterior condyloid foramen.

Fig. 100.



Fig. 101.



Fig. 102.



the internal occipital protuberance. To the crucial ridges, the tentorium and flax are attached, as the expression is, as will be described hereafter.

Connections.—The occipital bone is articulated with six others—the sphenoid, two temporal, two parietal, and the atlas, the upper vertebræ of the spinal column.

Fig. 100 represents the internal and upper surface of the *sphenoid*, which is situated directly in front of the occipital; its name is derived from its being wedged between the other bones. It is a symmetrical bone; viz., composed of two similar

halves; it is also composed of a body in the centre and a greater and lesser wing on each side; its upper surface is remarkable, 1st, for a deep fossa near its centre, 10, called the *sella turcica*, in which is lodged a part of the brain called pituitary gland, though it is not a proper gland; 2d, for the bevelled edges 22 and 16, by which it overlaps the lower edges of the temporal and parietal bones, and acts as a “strainer” or “binder” to prevent them from spreading when force acts upon them; a beautiful architectural device.

Fig. 98.—The external surface of the occipital bone. 1. The superior curved line. 2. The occipital protuberance. 3. The spine. 4. The inferior curved line. 5. The foramen magnum. 6. The condyle of the right side. 7. The posterior condyloid fossa in which the posterior condyloid foramen is found. 8. The anterior condyloid foramen, concealed by the margin of the condyle. 9. The transverse process; this process upon the internal surface of the bone forms the jugular eminence. 10. The notch in front of the jugular eminence which forms part of the jugular foramen. 11. The basilar process. 12, 12. The rough projections into which the odontoid ligaments are inserted.

Fig. 101 represents the external or under surface of the sphenoid, and is remarkable for, 1st, the long processes 13, 15, called pterygoid; one delicate branch of which, 14, is formed into a hook called hamular process, round which, as a pulley, turns the tendon of the tensor palati muscle; 2d, the sharp ridge, crest, or beak 1, 2. The body is remarkable for the large cells found in it.

Connections.—It articulates with all the bones of the cranium.

Fig. 102 represents the *ethmoid* bone, seen from above and behind; its name is derived from the sieve-like appearance of its upper surface, 4; it is a symmetrical cuboidal bone, composed of a cribriform plate and two lateral masses, in which there are many cells. This bone is situated on the median line in front of the sphenoid, and forms the roof of the nose; it is, indeed, as much a facial as a cranial bone. Its upper part only belongs to the cranium; its lower part will be spoken of in connection with the bones of the face; it is remarkable for its punctured plate, thro' which the nerves of smell extend, and for its lightness as it floats on water.

Connections.—It ar-

Figs. 103 & 104.

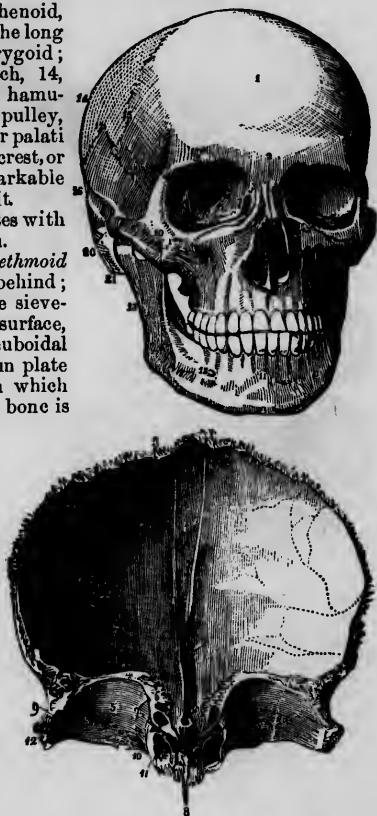


Fig. 99.—The internal surface of the occipital bone. 1. The left cerebral fossa. 2. The left cerebellar fossa. 3. The groove for the posterior part of the superior longitudinal sinus. 4. The spine for the falx cerebelli, and groove for the occipital sinuses. 5. The groove for the left lateral sinus. 6. The internal occipital protuberance which lodges the torcular Herophilli. 7. The foramen magnum. 8. The basilar process, grooved for the medulla oblongata. 9. The termination of the groove for the lateral sinus, bounded externally by the jugular eminence. 10. The jugular fossa; this is completed by the petrous portion of the temporal bone. 11. The superior border. 12. The inferior border. 13. The border which articulates with the petrous portion of the temporal bone. 14. The anterior condyloid foramen.



Figs. 105 & 106.



ticulates with the frontal and sphenoid, and eleven bones of the face.

Fig. 103 represents an external, and Fig. 104 an internal, view of the *frontal* bone, named from its situation. It is a symmetrical bone, and remarkable for, 1st, the superciliary ridge 2, 3, and notch 3; 2d, its sinuses called frontal—situated within the ridge 2, 3, and opening into the nose. They exist only very unfrequently in females; their size varies from the diameter of a straw to half an inch; 3d, forming the vault of the eye-socket.

Connections.—It articulates with twelve bones—the two parietal, the ethmoid and sphenoid, and eight bones of the face.

Fig. 105 represents the external, and 106 the internal, surfaces of the *temporal* bones. They are named from their situations. There are two: each is divided into three parts—the squamous, mastoid, and petrous.

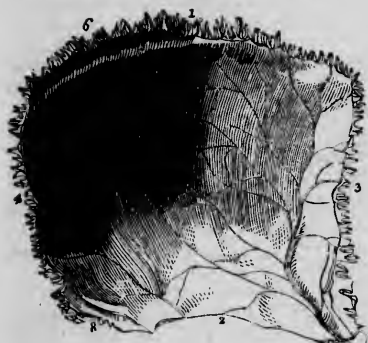
Fig. 100.—The superior or cerebral surface of the sphenoid bone. 1. The processus olivaris. 2. The ethmoidal spine. 3. The lesser wing of the left side. 4. The cerebral surface of the greater wing of the same side. 5. The spinous process. 6. The extremity of the pterygoid process of the same side, projecting downwards from the under surface of the body of the bone. 7. The foramen opticum. 8. The anterior clinoid process. 9. The groove by the side of the serra turcica; for lodging the internal carotid artery, cavernous plexus, cavernous sinus, and orbital nerves. 10. The sella turcica. 11. The posterior boundary of the sella turcica: its projecting angles are the posterior clinoid processes. 12. The basilar portion of the bone. 13. Part of the sphenoidal fissure. 14. The foramen rotundum. 15. The foramen ovale. 16. The foramen spinosum. 17. The angular interval which receives the apex of the petrous portion of the temporal bone. The posterior extremity of the Vidian canal terminates at this angle. 18. The spine of the spinous process; it affords attachment to the internal lateral ligament of the lower jaw. 19. The border of the greater wing and spinous process, which articulates with the anterior part of the squamous portion of the temporal bone. 20. The internal border of the spinous process, which assists in the formation of the foramen lacerum basis cranii. 21. That portion of the greater ala which articulates with the anterior inferior angle of the parietal bone. 22. The portion of the greater ala which articulates with the orbital process of the frontal bone.

Fig. 101.—The antero-inferior view of the sphenoid bone. 1. The ethmoid spine. 2. The rostrum. 3. The sphenoidal spongy bone, partly closing the left opening of the sphenoidal cells. 4. The lesser wing. 5. The foramen opticum piercing the base of the

107.



108.



The first two are seen externally. The squamous portion is remarkable for, 1st, its smooth, slightly convex surface 1: 2d, its thinness, being the thinnest part of the cranium; hence the great danger of blows upon this part of the head—both on account of fracture and violently jarring the brain; 3d, its bevelled edge overlapping the parietal bone above; 4th, its long process called zygoma, so easily felt above the articulation of the lower jaw; 5th, the temporal fossa formed behind the zygoma, in which the lower and thick part of the temporal muscle is found. The mastoid portion is remarkable for, 1st, its prominence called the mastoid process, felt just behind and below the ear; 2d, the cells exhibited within it; they open into the ear. This bone is also remarkable, externally, for exhibiting the passage 15, leading to the ear and the socket for the lower jaw. 7 Inferiorly is seen 11, a long

lesser wing. 6. The sphenoidal fissure. 7. The foramen rotundum. 8. The orbital surface of the greater wing. 9. Its temporal surface. 10. The pterygoid ridge. 11. The pterygo-palatine canal. 12. The foramen of entrance to the Vidian canal. 13. The internal pterygoid plate. 14. The hamular process. 15. The external pterygoid plate. 16. The foramen spinosum. 17. The foramen ovale. 18. The extremity of the spinous process of the sphenoid.

Fig. 102.—The ethmoid bone seen from above and behind. 1. The central lamella. 2. 2. The lateral masses; the numbers are placed on the posterior border of the lateral mass at each side. 3. The crista galli process. 4. The cribriform plate of the left side, pierced by the cribriform foramina. 5. The hollow space immediately above and to the left of this number, is the superior meatus. 6. The superior turbinated, 7. The middle turbinated bone; the numbers 5, 6, 7, are situated upon the internal surface of the left lateral mass, near its posterior part. The interval between these parts is the superior meatus. 8. The external surface of the lateral mass, or os planum. 9. The superior or frontal border of the lateral mass, grooved by the anterior and posterior ethmoidal canals. 10. Refers to the concavity of the middle turbinated bone, which is the upper boundary of the middle meatus.

Fig. 103.—A front view of the skull. 1. The frontal portion of the frontal bone

Fig. 109.



slender styloid process; internally, the petrous portion of the bone is conspicuous. It is remarkable for containing the internal organs of hearing, among which could be counted four bones in each ear—which are to be described with the ear. The whole inner surface of the bone is very irregular, presenting many processes, and fossæ; and also when in its place, many holes, fissures, &c., among which

the carotid canal is worthy of notice from its tortuous character, and its being the situation of a part of the carotid artery, through which the oxygenated blood flows to the brain.

The 2. immediately over the root of the nose, refers to the nasal tuberosity; the 3. over the orbit, to the supra-orbital ridge. 4. The optic foramen. 5. The sphenoidal fissure. 6. The speno-maxillary fissure. 7. The lachrymal fossa, in the lachrymal bone, the commencement of the nasal duct. The figures 4, 5, 6, 7, are within the orbit. 8. The opening of the anterior nares, divided into two parts by the vomer; the number is placed upon the latter. 9. The infra-orbital foramen. 10. The malar bone. 11. The symphysis of the lower jaw. 12. The mental foramen. 13. The ramus of the lower jaw. 14. The parietal bone. 15. The coronal suture. 16. The temporal bone. 17. The squamous suture. 18. The upper part of the great ala of the sphenoid bone. 19. The commencement of the temporal ridge. 20. The zygoma of the temporal bone, assisting to form the zygomatic arch. 21. The mastoid process.

Fig 104.—The internal surface of the frontal bone: the bone is raised in such a manner as to show the orbito-nasal portion. 1. The grooved ridge for the lodgment of the superior longitudinal sinus and attachment of the falx. 2. The foramen cæcum. 3. The superior or coronal border of the bone; the figure is situated near that part which is bevelled at the expense of the internal table. 4. The inferior border of the bone. 5. The orbital plate of the left side. 6. The cellular border of the ethmoidal fissure. The foramen cæcum (2) is seen through the ethmoidal fissure. 7. The anterior and posterior ethmoidal foramina; the anterior is seen leading into its canal. 8. The nasal spine. 9. The depression within the external angular process (12) for the lachrymal gland. 10. The depression for the pulley of the superior oblique muscle of the eye; immediately to the left of this number is the supra-orbital notch, and to its right the internal angular process. 11. The opening leading into the frontal sinuses. The same parts are seen upon the opposite side of the figure.

Fig. 105.—The external surface of the temporal bone of the left side. 1. The squamous portion. 2. The mastoid portion. 3. The extremity of the petrous portion. 4. The zygoma. 5. Indicates the tubercle of the zygoma, and at the same time its anterior root turning inwards to form the eminentia articularis. 6. The superior root of the zygoma, forming the posterior part of the temporal ridge. 7. The middle root of the zygomata terminating abruptly at the glenoid fissure. 8. The mastoid foramen. 9. The meatus auditorius externus, surrounded by the processus auditorius. 10. The digastric fossa, situated immediately to the inner side of (2) the mastoid process. 11. The styloid process. 12. The vaginal process. 13. The glenoid or Glasserian fissure; the leading line from this number crosses the rough posterior portion of the glenoid fossa. 14. The opening and part of the groove of the Eustachian tube.

Fig. 106.—The left temporal bone, seen from within. 1. The squamous portion. 2. The mastoid portion. The number is placed immediately above the inner opening of the mastoid foramen. 3. The petrous portion. 4. The groove for the posterior branch of the arteria meningea media. 5. The bevelled edge of the squamous border

Connections.—It articulates with the occipital, the parietal, the sphenoid, and two facial bones.

Fig. 107 represents the external, and 108 the internal, surface of the *parietal* bones. They are named from their forming so large a part of the sides of the cranium; they are two in number—the right and left. The external surface is rather smooth, convex, and remarkable only for its central protuberance, and the curved temporal ridge to which the temporal muscle is attached. The internal surface is concave, quite smooth, except that it is grooved for blood-vessels.

Connections.—The two parietal bones are articulated together at the median line at the top of the cranium, forming what is called the sagittal suture—they form, therefore, the central vault of the cranium; they also articulate with the temporal bones, with the sphenoid, forming squamous sutures; with the occipital, forming the lambdoid suture; and with the frontal, forming the coronal suture. By articulation with the sphenoid, they complete the circuit of the cranium in that region, and any pressure upon the summit cannot spread out the arch as long as the sphenoid abutments hold.

It only remains to mention the *ossa triquetra* or Wormiana (see Fig. 9). These are names given to small portions of the fibrous table which are separated by sutures from the rest of it. They are not often seen in the inner table. Sometimes there are none in the outer, and sometimes fifty to a hundred exist usually near to the lambdoid suture. Their use, or the cause of their existence, is not known. It may be proper to draw attention to the great number of foramina to be seen at the base of the skull—some are “fissures,” some “lacerated,” and many cylindrical. In them exist parts of vessels and nerves, which communicate between the brain and the other parts of the body.

of the bone. 6. The zygoma. 7. The digastric fossa immediately internal to the mastoid process. 8. The occipital groove. 9. The groove for the lateral sinus. 10. The elevation upon the anterior surface of the petrous bone marking the situation of the perpendicular semicircular canal. 11. The opening of termination of the carotid canal. 12. The meatus auditorius internus. 13. A dotted line leads upwards from this number to the narrow fissure which lodges a process of the dura mater. Another line leads downwards to the sharp edge which conceals the opening of the aquæductus cochleæ, while the number itself is situated on the bony lamina which overlies the opening of the aquæductus vestibuli. 14. The styloid process. 15. The stylo-mastoid foramen. 16. The carotid foramen. 17. The jugular process. The deep excavation to the left of this process forms part of the jugular fossa, and that to the right is the groove for the vein of the cochlea. 18. The notch for the fifth nerve upon the upper border of the petrous bone, near to its apex. 19. The extremity of the petrous bone which gives origin to the levator palati and tensor tympani muscles.

Fig. 107.—The external surface of the left parietal bone 1. The superior or sagittal border. 2. The inferior or squamous border. 3. The anterior or coronal border. 4. The posterior or lambdoidal border. 5. The temporal ridge; the figure is situated immediately in front of the parietal eminence. 6. The parietal foramen, unusually large in the bone from which this figure was drawn. 7. The anterior inferior angle. 8. The posterior inferior angle.

Fig. 108.—The internal surface of the left parietal bone. 1. The superior or sagittal border. 2. The inferior or squamous border. 3. The anterior or coronal border. 4. The posterior or lambdoidal border. 5. Part of the groove for the superior longitudinal sinus. 6. The internal termination of the parietal foramen. 7. The anterior inferior angle of the bone, on which is seen the groove for the trunk of the *arteria meningea media*. 8. The posterior inferior angle, upon which is seen a portion of the groove for the lateral sinus.

381. The *facial bones* form a very complicated portion of the skull, and occupy all the lower front part of it. The cranium is essentially a single cavity, but the facial bones form three partial ones of notable consequence, and many of minor importance.

382. The *facial bones are divided* into two classes: 1st. The *lower jaw* is a single bone, united to the temporal bone by a movable joint of a compound character, and supplied with interarticular cartilages; 2d. The upper jaw is composed of thirteen bones, united by suture joints so immovable that the whole seems to be a single mass. There is one bone of the thirteen unmated: the rest form six pairs, of which the superior maxillary are the chief—all the rest are accessory; they contribute to form the conoidal sockets, which protect the eyes—the two passages of the nose; they give insertion to the upper teeth, and form the vault or roof of the mouth.

Fig. 110.



The facial bones are so irregular in size and form, that it is almost impossible to describe them briefly, or represent them satisfactorily, yet their practical importance permits but a few words to be said of them.

Fig. 110 represents the external surface of the superior maxillary bone. It is remarkable for, 1st, its malar process 7, ordinarily called the cheek bone; 2d, the orbital plate 3 of the eye socket; 3d, the nasal process 8; forming 4th, the wall of the nasal cavity 9; 5th, its lower edge hollowed out into the sockets, or alveoli, for receiving the teeth. Internally it exhibits a large cavity, called the antrum, from which a short canal opens into

Fig. 110.—The superior maxillary bone of the right side, as seen from the lateral aspect. 1. The external, or facial surface; the depression in which the figure is placed

Which part of the head do the facial bones form? How many cavities do they form? Into how many classes are they divided? How many form the upper part of the face? How many are in pairs? Describe fig. 110.

the nose. The long roots of the cuspid teeth reach nearly to the antrum and sometimes open into it, and in disease of the antrum, an opening is sometimes made by extracting a tooth, and thrusting a probe into the antrum.

Connections.—It is articulated with the frontal and ethmoid of the cranium, with all the facial, and with eight teeth.

Next in conspicuousness externally, is the *malar* bone 10, fig. 103. It is remarkable for, 1st, its zygomatic process, by which it is attached to the temporal bone, as is easily felt upon the upper side of the face; 2d, its orbital process and plate, the first of which forms the edge of the lower and outer part of the socket, as is easily felt.

Connections.—It articulates with the frontal, temporal, and maxillary.

The *nasal* bones are two in number, and form the upper part of the ridge of the nose.

Connections.—They articulate with each other, with the frontal, the ethmoid, and the maxillary. The cartilages which form the lower part of the sides of the nose are also connected with them.

The *ossa unguis* are named from their resembling a nail in form, thinness, and semi-transparency. They are situated at the inner and front part of the eye socket. They articulate with the frontal, ethmoid, maxillary, and turbinated bones.

Fig. 111 represents a back view of the right *palate* bone. It is composed of two parts—1st, the perpendicular; 2d, the horizontal. The inner surface 2 forms the wall of the back part of the nasal passage, while 1 is the floor of the nose. Fig. 112 represents the surface on the otherside of 2, or back of it, and also back of but against

Fig. 111.



Fig. 112.



is the canine fossa. 2. The posterior, or zygomatic surface. 3. The superior, or orbital surface. 4. The infra-orbital foramen; it is situated immediately below the number. 5. The infra-orbital canal, leading to the infra-orbital foramen. 6. The inferior border of the orbit. 7. The malar process. 8. The nasal process. 9. The concavity forming the lateral boundary of the anterior nares. 10. The nasal spine. 11. The incisive, or myrtiform fossa. 12. The alveolar process. 13. The internal border of the orbital surface, which articulates with the ethmoid and palate bone. 14. The concavity which articulates with the lachrymal bone, and forms the commencement of the nasal duct. 15. The palate process. *a*. The two incisor teeth. *c*. The canine. *b*. The two bicuspidati. *m*. The three molars.

Fig. 111.—A posterior view of the palate bone in its natural position; it is slightly

What is the antrum, and where is it? With what bones is the maxillary articulated? Where is the malar bone found? Where are the nasal bones? Describe the *ossa unguis*? Describe fig. 111.

the maxillary bone fig. 110, which might be brought down over it as they now stand.

Connections.—The palate bones articulate together, and with the sphenoid, ethmoid, maxillary, vomer, and inferior turbinated.

Turbinated is a name given to distinguish two bones and four processes of the ethmoid bone which are found projecting into the nasal cavity. The name is given on account of their somewhat coiled appearance. There is an inferior, which is a distinct bone, and a middle and superior, which are processes, in each nasal cavity. Their use is to increase the extent of surface of the lining of the nose, and thereby cause the air to act and to be acted upon more extensively, and thus intensely affect the nerves on one hand, and be itself warmed on the other.

Connections.—The inferior turbinated bones are articulated with the maxillary, the palate, the ethmoid, and the unguis.

Vomer is the name, from its resemblance to a ploughshare of olden time, given to the division bone of the nose, by which, for the purposes of smell, the nose becomes two noses.

Connections.—It is articulated with the sphenoid, ethmoid, maxillary, and palate bones, and with the cartilage of the septum.

The nose is formed by the ethmoid above, the nasal at the upper part, the palate and maxillary at the sides and floor, divided by the vomer into two fossæ, canals, or passages, each of which is partially divided by three turbinated bones, leaving between them spaces called meatuses, and the whole is finished by the cartilages. Opening into each cavity of the nose are five important canals, one leading from the antrum of Highmore—one from the eye, through which the

turned to one side to obtain a sight of the internal surface of the perpendicular plate (2). 1. The horizontal plate of the bone; its upper or nasal surface. 2. The perpendicular plate; its internal or nasal surface. 3, 10, 11. The pterygoid process or tuberosity. 4. The broad internal border of the horizontal plate which articulates with the similar border of the opposite bone. 5. The pointed process, which, with a similar process of the opposite bone, forms the palate spine. 6. The horizontal ridge which gives attachment to the inferior turbinated bone; the concavity below this ridge enters into the formation of the inferior meatus, and the concavity (2) above the ridge into that of the middle and superior meatus. 7. The speno-palatine foramen. 8. The orbital portion. 10. The middle facet of the tuberosity, which enters into the formation of the pterygoid fossa. The facets 11 and 3 articulate with the two pterygoid plates,—11 with the internal, and 3 with the external.

Fig. 112.—The perpendicular plate of the palate bone seen upon its external or speno-maxillary surface. 1. The rough surface of this plate, which articulates with the superior maxillary bone. 2. The posterior palatine canal, completed by the tuberosity of the superior maxillary bone. The rough surface to the left of the canal (2) articulates with the internal pterygoid plate. 4. The speno-palatine foramen. 4, 5, 6. The orbital portion of the perpendicular plate. 4. The speno-maxillary facet of this portion; 5. its orbital facet; 6. its maxillary facet, to articulate with the superior maxillary bone. 7. The sphenoidal portion of the perpendicular plate. 8. The pterygoid process or tuberosity of the bone.

Fig. 113.—The lower jaw. 1. The body. 2. The ramus. 3. The symphysis. 4. The fossa for the depressor labii inferioris muscle. 5. The mental foramen. 6. The exter-

Describe fig. 112. To what bones is the name turblinated given? What is their use? Where is the vomer found? By what bones are the nasal cavities formed? What cavities open into the nose? Describe fig. 113

waste tear fluid flows off—one from the frontal sinus—one or more from the ethmoidal sinuses or cells—one from the ear—besides several small ones.

Fig. 113 represents the lower jaw; it is articulated by the process 11 to the temporal bone. The joint allows motion up and down, backward and forward, and from side to side, and is furnished with an interarticular cartilage. The process 10 is situated back of the zygomatic process and in the temporal fossa, and is attached to the tendon

of the temporal muscle, which is one of the most important in the ordinary motion of the jaw. The jaw completes the framework of the face, the cavity of the mouth being closed by the muscles of the tongue and cheeks.

Elastic Protections.

383. The *spinal column* is composed of four very distinct classes of parts: 1st, bones; 2d, cartilages; 3d, synovial membranes; 4th, ligaments.

384. The *bones* are called *vertebræ*, each of which is composed of a body, laminae, and articulating, lateral, and spinous processes.

Fig. 114 represents the upper surface of a vertebra. *b* is the body; its upper surface is a little concave; in front it is convex; behind it is slightly concave; internally it is full of cancelli, in health filled with marrow. *ll* are two laminae, which extend back from the sides of the body, and curving around, meet to form a hole or short canal, of which the body forms the front part. *lp* are lateral processes, which, in this case are slightly bifurcated. *s* is a spinous process.

Fig. 113.

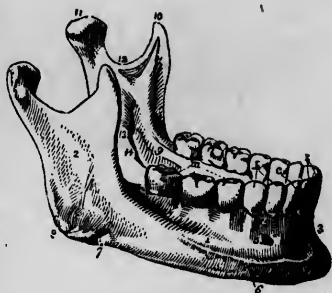
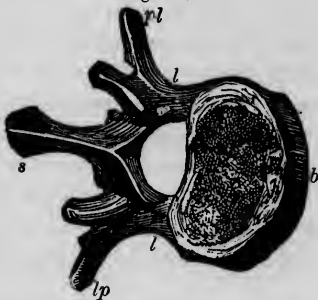


Fig. 114.



nal oblique ridge. 7. The groove for the facial artery. 8. The angle. 9. The extremity of the mylo-hyoidean ridge. 10. The coronoid process. 11. The condyle. 12. The sigmoid notch. 13. The inferior dental foramen. 14. The mylo-hyoidean groove. 15. The alveolar process. *i*. The middle and lateral incisor tooth of one side. *c*. The canine tooth. *b*. The two bicuspids. *m*. The three molars.

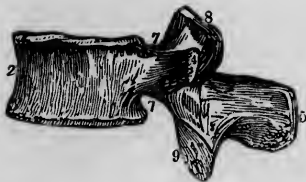
Fig. 115.



Fig. 115 represents the side appearance of another vertebra. 1 is the body slightly constricted; 2, lamina which has not so much depth as the body, and therefore leaves a notch, 5; 3, root of the lateral process, 7. 6, spinous process; 8 and 9, articulating processes, four in number, two superior, and two inferior.

Fig. 116 represents still another vertebra. 2, body; 7, lamina and notch; 4, lateral; 8 and 9, articulating; and 5, spinous processes.

Fig. 116.



385. The *spinal cartilages* are of two kinds. 1st. One joins, and at the same time separates the bodies of neighboring vertebræ, and is from its position called inter-

vertebral substance. Its diameters correspond to those of the bodies to which it is attached. In thickness it varies according to its position and treatment, from that of paper to half an inch. Its circumference is slightly convex or concave, according as it is compressed or extended. *Composition.* For some distance from its surfaces it is composed of white fibres, which are in one direction perpendicular and in another oblique, crossing each other, thus forming a very compact yet elastic mass. The central part is gelatinous in consistence, and contains some cells. This cartilage is, therefore, a fibrous ligament of a peculiar structure, exceedingly elastic and sensitive to pressure, and at the same time enduring great or continued pressure, and never resilient,

Of what classes of parts is the spinal column formed? Of what parts are the bones composed? Describe fig. 114. Describe figs. 115, 116. How many kinds of spinal cartilages? Where is the first variety found? What is its composition?

but gently returning to its proper uncompressed condition when weight is removed. It is one of the most remarkable structures in the body. 2d. The *articulating processes* are incrustated with the ordinary cartilage of the joints.

386. The *synovial capsules* exist only in the joints of the articulating processes; they are very extensive, as considerable extent of gliding motion is required.

387. *Spinal ligaments* are of two kinds (if the intervertebral substance is counted as one, there are three), the non-elastic or white, and the yellow or elastic. The white has three positions, anterior, posterior, and spinous. The anterior extends from one body to another, nearly enveloping the outside. Some of its fibres merely pass from one body to another, while the longer ones pass over several. They adhere to the discs between, as well as to the bodies. The posterior ligament is on the posterior surface of the body, and in the spinal canal. They are both very strong, and inextensible. The spinous ligaments connect between the spinous processes. The yellow ligament exists between the laminæ of the vertebræ, and is called from its color the subflava. It is very strong, but very elastic, and upon it, erectness, to a considerable degree, depends. Its fibres are curiously and obliquely arranged, so as to give them greater length, and of course more elasticity than they would have if passing directly across from bone to bone.

388. *The spinal column is divisible* into regions, called, 1st, cervical, embracing 7 bones; 2d, dorsal, 12 bones; 3d, lumbar, 5 bones; 4th, sacral, 5 bones; 6th, coxycgeal, 4 bones. See Fig. 95.

Why does the central gelatinous substance improve the disc? What is the degree of the suddenness with which the disc, after compression, returns to its proper thickness? What and where is the second kind of cartilage? Where, in the spinal column, are synovial capsules found? How many kinds of spinal ligaments are there? Where are they situated? Into what regions is the spinal column divisible?

Fig. 117.

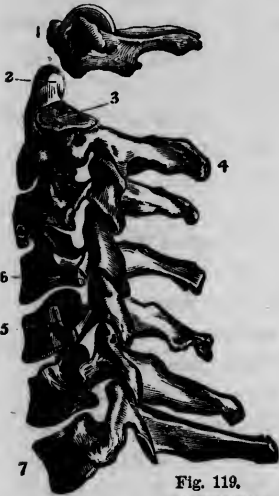


Fig. 119.

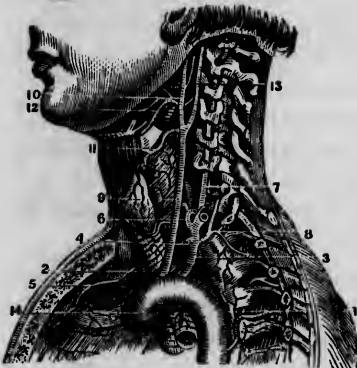


Fig. 118.



Fig. 120.



Fig. 121.



Fig. 118.—A central cervical vertebra, seen upon its upper surface. 1. The body, concave in the middle, and rising on each side into a sharp ridge. 2. The lamina. 3. The pedicle, rendered concave by the superior intervertebral notch. 4. The bifid spinous process. 5. The bifid transverse process. 6. The vertebral foramen. 7. The superior articular process. 8. The inferior articular process.

Fig. 120.—The upper surface of the atlas. 1. The anterior tubercle

projecting from the anterior arch. 2. The articular surface for the odontoid process upon the posterior surface of the anterior arch. 3. The posterior arch, with its rudimentary spinous process. 4. The intervertebral notch. 5. The transverse process. 6. The vertebral foramen. 7. Superior articular surface. 8. The tubercle for the attachment of the transverse ligament.

Fig. 121.—A lateral view of the axis. 1. The body. 2. The odontoid process. 3. The smooth facet on the anterior surface of the odontoid process which articulates with the anterior arch of the atlas. 4. The lamina. 5. The spinous process. 6. The transverse process pierced obliquely by the vertebral foramen. 7. The superior articular surface. 8. The inferior articular process.

The bodies of the *cervical vertebrae* are small; the discs between them are thin, but more so at the back part. The laminae are long and slender, the articulating surfaces nearly horizontal; the lateral processes are anterior to the articulating, and perforated for the situation of the vertebral artery: see 6. fig. 118, and 7. fig. 119.

The *upper two cervical vertebrae* require description, as the head rests upon the upper, called the atlas, fig. 120, being jointed so as to allow the nodding motion of the head. The central hole of this bone is large, and divided into two by a ligament. One of these is occupied by the spinal cord, the other by the pivot of the second vertebra, around which the atlas turns, moving the head of course in like manner. The summit of the pivot is fastened to the occipital bone of the cranium by a ligament, so that displacement is impossible. By the motions of the other vertebra a twisting movement is obtained; by these, two direct motions are readily produced.

The *dorsal vertebrae*. The bodies are thicker than those of the neck, increasingly so. They present articulating facets to the ribs, 4, fig. 123. The discs are thicker behind than in front. The laminae become stouter. The lateral processes present facets, 5, for connection with the ribs; the articulating surfaces are nearly perpendicular, 7, 6. Those of the bone above shutting over those below. The spinous processes, 3, are bony, and very much inclined downward.

Lumbar vertebrae, fig. 124. The bodies are large and thick. The discs correspond, being very thick at the front part. The laminae are stout. The lateral processes are short and stout. The articular processes are obliquely situated, and interlock. The spinous processes are very stout and nearly horizontal.

The *sacrum* is composed of five, consolidated vertebrae, the size of which rapidly diminishing from above downward, gives the sacrum the form of a wedge. Fig. 125 represents a view of the upper and front

Fig. 123.



Describe fig. 117, 118, 119, 120, 121. What is the difference between the body of a cervical and dorsal vertebra? Wherein do the two upper cervical vertebra differ from the rest? What motions are obtained by means of the cervical vertebra? How do the dorsal processes differ from the cervical or lumbar?

surfaces; 1, surface for attachment of disc between the sacrum and the lower dorsal vertebrae; 2, surface attached to coccyx; 3, body of

Fig. 124.

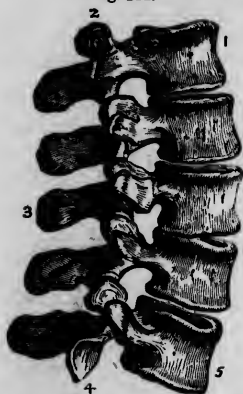
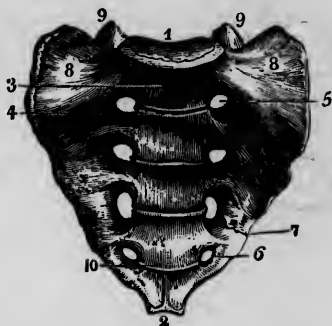
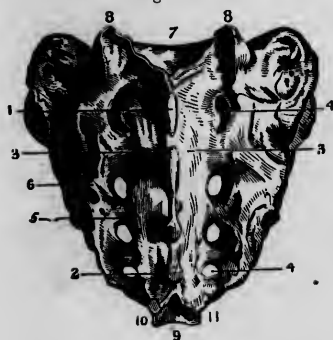


Fig. 125.



the sacrum; 4, 10, lines marking its divisions; 5, 6, sacral holes for nerves, corresponding to intervertebral foramina; 7, notch; 8, wings; 9, articulating processes. Fig. 126 is a back view of the same bone;

Fig. 126.



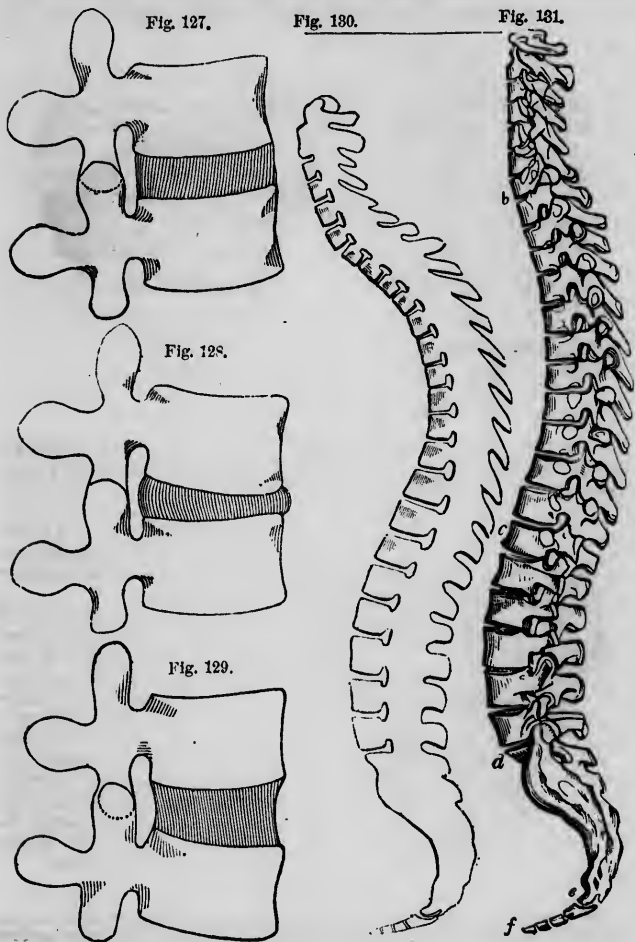
7, articular face for the lower lumbar vertebrae; 9, for the coccyx; 8, articulating process; 4, 4, sacral holes for posterior sacral nerves.

The *coccyx* is composed of four unimportant bones, often consolidated into one, and also with the sacrum. Often they are included under the name sacrum. When they are numerous, they form the caudal appendage of many animals. In fish the distinction between them, the sacrum and the vertebra proper, cannot readily be made. *Coccyges* is the plural name given to these bones.

What is the comparative size of the bodies of the lumbar vertebrae? Are the upper and lower surfaces of the lumbar bodies convex or concave? How many vertebrae compose the sacrum? Describe figs. 125, 126. What and where is the coccyx.

Of the Spinal Column Generally.

389. By the *spinal column* is usually meant those movable



parts above the sacrum upon which the column is said to rest. It is composed of twenty-four vertebræ, twenty-three discs, and of articular cartilages, synovial capsules, and ligaments.

This structure is one of the most admirable pieces of mechanism in the world, and on account of its uses and what is dependent upon its perfection, is perhaps, to all classes of persons the most intensely interesting of any part of the body—for upon its perfection the erectness and comeliness of form is chiefly, and gracefulness of movement is to a great degree, dependent. It will be proper, therefore, to consider it at some length.*

390. *The spinal column requires particular notice* in respect to four things:—1st, its form; 2d, as a support to the parts resting upon it; 3d, as a protection to the parts within and above it; 4th, as a motor apparatus.

391. *The perfection of form* is dependent slightly upon the bones, but chiefly upon the discs and ligaments.

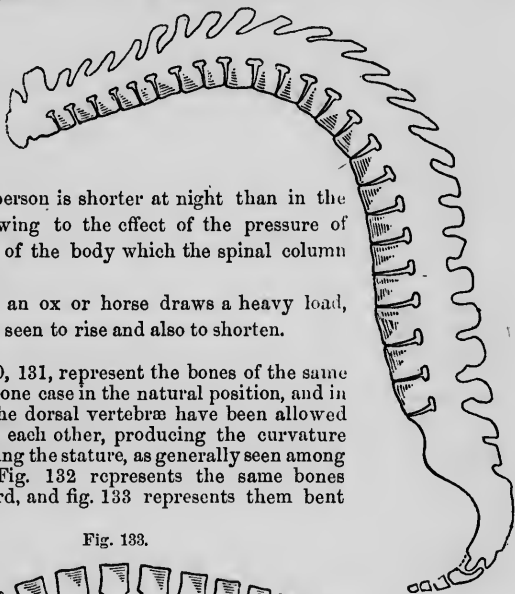
In case of rickets and absorption of the bones from any cause, remarkable deformity is of course produced, but all ordinary curvatures are dependent upon the discs.

* This subject is all the more important on account of the incorrect popular notions in regard to deformities of the spinal column and prominence of the shoulders. These have been inculcated or cultivated by the quacks of the day, who wish to speculate on the misled ignorance of the public. But what is still worse, the same erroneous ideas are taught in some books "prepared for schools," the authors of which apparently know no better. Nor is such ignorance excusable, for correct ideas on this subject are not the offspring of to-day. They are correctly, and at length set forth at least by Cruveilhier, whose works should be familiar to any one who pretends to write on Anatomy. Nor are any of our good authorities silent on this subject. Worst of all, pictures are invented to impress on the mind of the pupil the importance of maintaining certain positions. The idea of these has been apparently taken from the impostors who palm upon the public their shoulder braces, mechanical supports, remedies, and other villainous contrivances. It is really too bad that the confidence of teachers, scholars, and the public, should be thus taken advantage of in respect to subjects of so great importance. Persons who do not understand physiology, have no right to write or speak upon it—errors in respect to it having such momentous results. I was exceedingly glad to observe in a report of the meeting of the American Institute, that a learned member of the medical profession, Dr. Hooker, of Connecticut, controverted the fallacy so generally taught and received out of the profession. I have judged this subject so important, as to add in the Appendix, some testimony from the best sources, which might be multiplied—the fact being, that the common sense inferences to be drawn from the structure of the body, are every where received and understood by scientific medical men.

What is usually included in the spinal column? Why is this structure very interesting to all? In what respects does the spinal column require particular notice? Its perfection of form chiefly dependent upon what? Describe figs. on page 289.

Illus.—a. If the stoutest man take upon his shoulders or head a heavy weight, his stature will be seen to shorten, which is owing to the compression of the spinal discs.

Fig. 182.

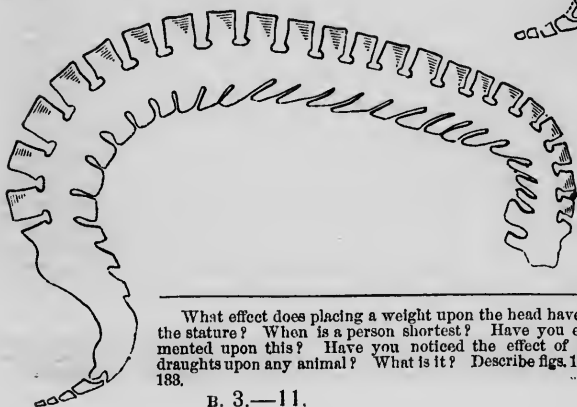


b. Any person is shorter at night than in the morning, owing to the effect of the pressure of those parts of the body which the spinal column supports.

c. When an ox or horse draws a heavy load, the back is seen to rise and also to shorten.

Figs. 130, 131, represent the bones of the same column, in one case in the natural position, and in the other, the dorsal vertebræ have been allowed to approach each other, producing the curvature and shortening the stature, as generally seen among females. Fig. 132 represents the same bones bent forward, and fig. 133 represents them bent

Fig. 133.



What effect does placing a weight upon the head have upon the stature? When is a person shortest? Have you experimented upon this? Have you noticed the effect of heavy draughts upon any animal? What is it? Describe figs. 132 and 133.

back. The same thing would result if the discs were added and natural in fig. 131, compressed very much in the dorsal region in fig. 130, and throughout the column in fig. 132, and extended in fig. 133.

Fig. 127, is a partially ideal representation of two vertebræ with the disc natural, viz., compressed only by the natural weight of the body. Fig. 128 represents the disc much compressed. Fig. 129, the same with all weight removed, and also extended.

Care must be taken not to conceive that the articulating processes act as pivots upon which the vertebræ turn. They are too delicate to bear the effect of much force. The mechanism of the motion, is this:—If the back is flexed forward, the front part of the disc is compressed, the central part is pushed back, and the back part of the disc of course somewhat thickened, and is the pivot; the posterior ligament, viz., upon the body of the vertebræ in the canal, restricts the separation of the vertebræ at that point; the yellow ligaments are at the same time stretched, and the capsules of the joints preventing the access of any thing to them, being made tense, cause the resistance of a vacuum to be produced. As soon therefore as the compressing cause is removed, the compressed front part of the disc, the thickened back part, the elastic ligaments and the pressure of the atmosphere, tend at once, forcibly, quickly, but gently, to restore the erectness of the column. If the column is flexed to either side, the same operations and forces are exhibited, though changed in direction. If the column is curved backward, the front part of the disc is stretched, the back part compressed; the anterior ligament now resists distension, while the posterior, elastic, and capsular are lax. There is therefore less power in the column to restore itself, and the powerful muscles which act through the long lever-like ribs, must add their assistance. The motion backward is restricted by the spinous and articulating processes. Those of the loins and neck, allow extensive motion, those of the back but little. The unprofessional world have been taught to believe that erectness chiefly depends upon the muscles of the back. This cannot, however, be true to any considerable degree, for—1st. Muscular action is always attended with considerable expenditure of substances, wherefore elastic tissues are used when they can be, and the discs can be made sufficient for the purpose indicated. 2d. Muscular action continued, is attended with discomfort, and the back must be supported the greater part of our waking hours. 3d. The muscles of the back are few in number, and small in collective size, compared with those of the lower extremities or of the neck. 4th. When

What would be the shape of the column if natural discs should be introduced? In which fig. would discs if introduced, be extended? What is the mechanism in operation and exhibited when the back is flexed forward? When to either side?

the head is large and must be supported, as in the cow, large elastic ligaments exist for the purpose. (See Fig. 27.) 5th. Experiment proves what theory indicates; for if every thing be removed from the spinal column, it not only maintains its erectness, but if forcibly flexed, will restore itself, and at the same time lift a large weight attached to its upper extremity. The muscles, therefore, rather guide than produce the erective motions of the back. They do however assist. But if the whole depended upon them, the practical conclusions would be the same; as what should be done for the health of the discs, should also be done for the good of the muscles.

392. The character of the discs and ligaments are dependent upon their natural constitution, upon the age and health of a person, and upon the treatment they receive.

Illus. a.—By similar compression of the chest, two persons will produce very different results; one will become very crooked, the other may have her erectness but slightly affected. By similar causes, one person will have his stature shortened an inch, while the shortening of another is scarcely observable.

Illus. b.—The front part of the discs in the lumbar region, are thicker than the back. This is especially noticeable in the case of the one between the sacrum and the vertebra. The discs of the dorsal region are just the reverse, while those of the neck are thicker at the front part. In the central part of the dorsal region, in the perfect form, the right side of the disc is slightly thicker than the left.

By these varying thicknesses of the discs, the proper curvatures of the column are produced, which should and do differ in different persons, as they render the column stronger and more elastic, and allow proper positions to the organs in the trunk. The slight curvature of the dorsal vertebræ to the right, is thought by Cruvelhier to be for the purpose of giving room to the aorta. Bichat thought it was owing to the great use of the right hand, and Beclard declares that in case of those who are left-handed, the curvature is to the left. The probable reason is, however, that the ribs of the right side may be elevated and thrown out a little more than the left, and the whole body properly balanced, the

What reasons are given to show that erectness does not chiefly depend upon muscles? Of what use are the muscles in respect to erectness? Upon what do the qualities of the discs and ligaments depend? Is the column quite erect laterally?

heavy and large liver being upon the right side. The practical results are, that the parts above and below must be slightly, though in a perfect form hardly perceptibly, curved in an opposite direction, and of course there is naturally a tendency in the column to curve badly when injurious influences act upon it.

393. *The effects of age* manifest themselves in infancy, when a person is growing rapidly, and in advanced life.

Illus. a.—The back of the infant is round.

This is because the discs have not yet become sufficiently firm to support weight. The action of the lungs, digestive organs, and indeed all the contents of the trunk, require that the back be curved at this period.

Inf.—Placing the hand against the back and pressing the child into an erect position must be injurious.

Illus. b.—The young person who is “growing” rapidly is usually “round-shouldered.”

This seems to be owing to the slow process of growth which takes place in such structures as the discs. But it is also noticeable, that such persons are soon out of breath, and exhausted generally with light labors. That the curved form of the column is not an injury, but a benefit and a necessity, we may well believe, since it is produced in the ordinary course of nature. Breathing is easier when the column is curved, than when erect; and other reasons may be given for what we see.

Inf.—When compressing clothing and supports are put upon the growing person, no good can, and much evil must, result.

Illus. c.—Old people sometimes become very crooked.

This is produced by the absorption and consolidation of the discs, which must result from the enfeebled circulation and digestion of old age. It ought to result, for the consolidated state of the bones would cause the brain to feel too severely the jars of even walking, if the column should be erect. There are several other reasons why the curvature should exist, and none why it should not.

394. *The effects of disease* upon the discs are proved

Where does the slight curvature to the right exist? Why? When does age exhibit peculiarities in the discs? Why should the child's back be round? What is the effect of *forcing* it to an erect position?

from peculiar forms of the column being associated with certain diseases.

Illus.—The slightly experienced eye can readily detect the consumptive or asthmatic patient by his form, which is very different from that of a person recovering from a tedious sickness, of the growing youth, of the sedentary person, or of old age.

Many, from seeing the curvature and disease associated, have mistaken the cause for the effect, and vice versa. It is not the curvature which produces the disease, but the reverse; indeed, with the disease the curvature is nature's own blessing; cure the disease, and the curvature disappears, just as, when the growing person gets strength proportioned to his stature, his form becomes erect and manly.

Inf.—It would be an absolute injury to make a person straight, if it could be done, while the disease continued.

395. The *use or treatment* of the discs and ligaments affects their ordinary character, more than any thing. *Any use or treatment which produces continued compression of the whole or any part of the disc, or extension of the ligaments, causes them to lose their natural elasticity, and to become permanently thinner in one case and longer in the other than is desirable.* WHATEVER COURSE, on the other hand, SUBJECTS THE DISCS AND LIGAMENTS, OR DIFFERENT PARTS OF THEM, TO ALTERNATE ACTION AND REPOSE, PERFECTS THEM CORRESPONDINGLY.

This must be so, from the nature of the case and the constitution of fibrous tissue. The discs do not contain blood-vessels, and the substance which nourishes them must slowly make its way into their interior. How can it pass into them compressed? If, however, as one part is compressed another is relieved from pressure or extended, the passage of substance into the uncompressed part will be facilitated; and if this action can be alternated upon the different parts, the desired perfect nutrition and excretion can be obtained. Facts, also, prove what is so clear even without them.

Is the form of the column the same in different diseases? Does the form produce the disease? Which should first be done—the disease removed, or the form corrected? What treatment of the discs makes them thinner? What perfects them?

Illus. a.—A French physiologist declares that a son of his lost an inch in stature by dancing one night, which was regained in a short time.

Illus. b.—Prof. Baird, of the Smithsonian Institute, told the author that, between eight o'clock in the morning and four in the afternoon, while hunting, his stature was diminished three-fourths of an inch, but the second morning after, he had regained his usual stature.

Illus. c.—Frequently a person's occupation can be judged from the curvature of the column, it being caused by constant compression of one part of the discs.

Illus. d.—Females are, nine cases in ten, more or less deformed, while a majority of men are erect.

Inf.—Whatever causes any position to be continued must be considered a cause of deformity, while frequent changes of positions must surely tend to produce erectness of figure, and gracefulness of spinal motion.

396. The great causes of deformity are fourfold: 1st. *Compression of the chest.* 2d. *Wearing the clothing suspended upon the region of the waist.* 3d. *Supports.* 4th. *Sedentary habits.*

If the chest be compressed, the necessary action of the ribs is, to produce continued pressure upon the front part of the intervertebral discs. The same result follows from the weight of the clothing acting through the ribs as levers; while if the chest be encased with whalebone or other supports, or if there be only "a few, just to keep the dress in place," the position of the dorsal portion cannot be much changed, and with fatigue must come *deformity*—for it is *deformity*, whether dressed in silks and satins or seen at the public hospital. That sedentary pursuits tend to similar results need not be argued. The person who takes but little exercise ought to have a curved spinal column. He ought to take more general exercise, and be straighter; but if he will not exercise, it is a blessing to be crooked.

397. *Every kind of general exercise, with clothing loose, supported upon the shoulders, and free from every kind of stiffening, and easy, frequently changed positions, tend*

What does a Frenchman testify in respect to his son? What does Professor Baird's experience prove? Who are most curved, men or women? What do you infer from what has been said in respect to deformity? What are its chief causes?

to produce an easy, elastic erectness, and mobility of the spine.

Inf.—If young ladies wish to be attractive by their comely forms or graceful movements, they must away with all things that constrict or support the chest, and take a great deal of exercise of various kinds.

398. The *more feeble* a person is, the more often and the longer does he require *repose* in order to promote the perfection of the spinal column.

One reason why men are more erect and less deformed than females is, that they repose themselves when sitting or standing, leaning in this direction or that, as is most comfortable; while females endeavor to *maintain* an erect position, and fail to gain the desired object by attempting it in the wrong manner. Young men "grow up" without being forced to "sit up" as young ladies are. Young ladies are also so dressed, that when they attempt to rest it must be in a constrained position, not an easy, graceful position of repose and comfort. The chest being compressed, and too small a quantity of air received for the perfection of the blood, the brain is oppressed, and they are inclined to inactivity and quietness in very bad positions—which, indeed, any position is if continued for too long a time. Deformities will again be noticed under the description of the chest.

399. As an *apparatus for protection*, we may notice, 1st, the cancelli of the bodies of the vertebræ filled with marrow; 2d, the elastic character of the twenty-three *thin* discs between the *thick* bodies;* 3d, the curvatures of the spine; and, 4th, the canal extending the whole length of the column proper, called the spinal, and also the rachidian canal.

It is the largest where the movements of the column are most extensive, and is slightly larger at the upper and lower part than at the middle of each vertebra. The lower edge of the lamina of each vertebra overlaps the upper part of the one below, so that an instrument enters the canal only with great difficulty and force.

* This is quite the reverse of what is seen under railroad cars—which, I suppose, is the reason why a patent was given!

Is it desirable for young ladies to be attractive? How can they become more so than usual? When do the discs require most repose? In what respects is the column adapted for protection? Where is the spinal canal largest?

receive the heads and tubercles of the ribs. 2d. Its elastic discs and ligaments. These assist in all the motions of the ribs. 3d. Its spinous processes. These being inclined, prevent harmful motion of the chest backward.

403. The *ribs* have sometimes been classed as true, false, and floating, according as their cartilages were connected directly with the sternum, to those above, or with nothing. But, as the names do not convey a correct idea, I shall class them as the *upper group*, of seven; the *middle group*, of three; and the *lower group*, of two ribs.

Sometimes there are but 22 ribs, and sometimes there are 26. There are as many in the male as in the female.

The *ribs* are *divided* into the head, neck, tubercle, angle, body, and anterior extremity. The *head* is divided by a line into two surfaces, each of which is attached to its own vertebra by means of a synovial and ligamentous capsule. The first, eleventh, and twelfth are attached to only one vertebra, and have but one surface. The *tubercle* corresponds to the facet of the process. Just in front of the tubercle, the rib curves abruptly and forms its *angle*. The bodies of the ribs differ from each other from the first to the twelfth. The first is short, stout, very much curved, and nearly flat horizontally. The ribs increase in length to the seventh, and then diminish to the twelfth; and from the horizontal, the flatness soon becomes perpendicular. The ribs are quite smooth externally and internally; they have a blunt, round edge upon the upper side, and a sharp, thin edge below, just within which a protective groove can be noticed. The eleventh and twelfth have no tubercle or groove, and are but little curved. The ribs have the external appearance of long bones, but internally they have not any canal, but cancelli. They have a great degree of elasticity for bone. The *position* of the ribs varies according to their relation to the first, which is nearly horizontal; they curve downward more and more, to the very lowest.

The *costal cartilages* have the same breadth and thickness as their ribs, but differ from each other very much in length. The first is very short, the seventh very long; those of the eighth, ninth, and tenth unite to those above them, and thus form a broad, irregular cartilage. Those of the eleventh and twelfth merely tip them. These cartilages are of the cellular character, and very elastic. They connect between the ribs and sternum, the first and second nearly hori-

Of what is the skeleton of the speaking apparatus composed? Of what is the skeleton of the chest composed? How is the dorsal portion of the chest-skeleton adapted to its purposes? How are the ribs grouped? What parts do ribs exhibit?

zonally; the rest turn upward more and more. They are very useful in all the motions of the chest.

The *sternum* in early life is composed of several bones, as indicated by the lines of the figure, but they are at last consolidated. The sternum remains however tipped with a cartilage, called the zypoid, till a very late period of life.

Skeleton of Chest, considered generally.

On account of the vital importance of air, as well as on account of speech, the chest and its contents always attract attention, and is worthy of particular notice, because of its effect upon the form and movement, and also because many incorrect notions prevail.

Fig. 135.

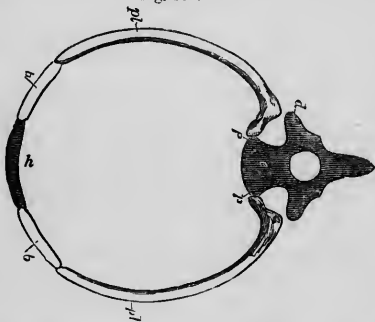


Fig. 135.—Ideal view of a vertebra, ribs, cartilages, and sternum. *c*, body; *p*, facet of the body; *d*, process which is, in fact, articulated with the rib; *pl*, body of rib; *b*, cartilage; *h*, sternum.

403. The size and form of the chest are determined by three

dimensions—its height, its lateral, and its antero-posterior diameters; and all these are at once affected by the positions of the ribs, which, of course, determine the capacity of the chest as well. The *positions of the ribs* are partly dependent on their own motions, and partly on those of the dorsal vertebrae.

404. When the *ribs are depressed*, the front of the chest is comparatively flat, and its capacity is correspondingly reduced. When they are elevated, the chest appears full and plump, and the capacity of the chest is enlarged. When the

Describe the costal cartilages? Where is the sternum? Why should the chest attract attention? Describe fig. 135. By what dimensions may the capacity of the chest be measured? Upon what motions are the positions of the ribs dependent?

ribs are depressed to the utmost degree of their own motion, a compression of the dorsal discs will allow them to fall so much lower. On the other hand, when they have been raised, the expansion of the dorsal discs will elevate them still more.

405. *Expansion* of the chest is therefore entirely dependent upon a perfectly free and extensive motion of the ribs and dorsal vertebræ, and perfect breathing depends upon the same things, and requires that the chest be made as small on the one hand, to expel the air, as it is made large on the other to inspire it. In other words, perfect breathing depends more upon *latitude of motion* than absolute size—indeed permanent size is not of especial value.

Whatsoever *constricts the chest*, not only injures breathing, but deforms.

If the ribs be pressed inward, they will also be pressed downward; this causes the dorsal discs to be constantly acted upon, and the curvature of fig. 130 is the result. But the ribs are a little less elastic or yielding on the right than on the left. The liver is on the right side, and the right cavity of the chest is usually a little broader than the left, the ribs upon that side not being quite as much depressed as on the left. When the chest is compressed, the left side, therefore, yields the most; the left side of the discs are most compressed becomes thinner than the other side, and thus lateral curvature is produced.

Fig. 186.



Whoever therefore, thinks a small waist agreeable, should remember that deformity is also connected with it necessarily. Besides, if the chest be not allowed free motions, the action of the person cannot be perfectly graceful and charming. The greatest care should be taken that the girl do not acquire the very erroneous idea that a small waist is a sign of gentility, and an improvement upon nature. The contracted waists of dolls which are given to children frequently, must early plant wrong ideas in their minds. The publishers of magazines, with deformed fashion plates, are not a little responsible, nor will they be held guiltless.

Fig. 137.

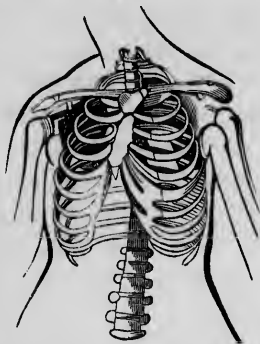
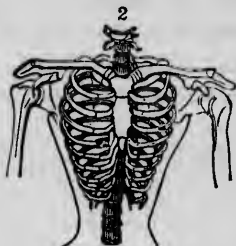


Fig. 138.



Here is an internal view, with the trappings removed. Fig. 138 is no exaggeration—it is an every-day reality—the result of the tight dresses, heavy skirts suspended about the waist, the whalebones worn in dresses, and sedentary habits. The young lady with chest like 138, all other things being similar, will not be, cannot be, any thing like as attractive as one whose chest is like 137. But other things will not be similar; a chest like that of 137, confers many beauties besides those of form. Let it be remembered that a freely moving, alternately expanded and diminished chest, is entirely different from the chest made large by fat. Fig. 138 does not exhibit all the deformity of the chest; the shoulders, especially the right one, project; the back is curved, and she has not her natural stature. I have now before me a skeleton in which all these deformities conspicuously exist. The discs of the dorsal region were so much compressed, and so constantly, that they had become as thin as paper, and as firm as bone itself. But we will return to this subject again.

B. Skeleton of the Vocalizing Apparatus.

406. The skeleton of the vocalizing apparatus, is composed of the *trachea*, *larynx*, and hyoid bone.

407. The trachea is composed of four-fifths of cartilaginous rings, connected by elastic ligament, which also completes the tube, which is therefore flattened behind. The

Describe figs. 136, 137, and 138. What produces such chests as 138? What other evils not apparent in 138, exist? What classes of parts form the skeleton of the speaking apparatus? Of what is the trachea composed?

length of the trachea is unimportant to consider; it differs in different persons, but cannot be materially affected by their efforts. Its elasticity can be improved by exercise.

408. The *skeleton of the larynx* is constructed of the *cricoid, thyroid, arytenoid* and *epiglottal* cartilages, the *cordæ vocales* and other ligaments, capsules, &c.

Fig. 139.

Fig. 139, represents a side view of the larynx and hyoid and a few rings of the trachea; *c*, cricoid, *t*, thyroid, *v*, its anterior inferior border, *d*, inferior, *b*, superior tubercle; *s*, superior, *r*, inferior horn; which has a synovial capsule connecting it to the cricoid; upon this, as a pivot, the thyroid turns; *n*, thyro-hyoid ligament; *u*, body; *z*, lesser, *v*, greater horn, of the hyoid bone.

Fig. 140 represents a side view of the larynx, 12, trachea; 9, 9, cricoid; 8 thyroid.

Fig. 141, view of cartilages separated; *c*, cricoid; *h*, its articular surfaces for receiving *a* of the arytenoid, *t*, thyroid which comes down upon *c*, and with its sides grasps the sides of *c*.

Fig. 142, cricoid cartilage; 1, its body; 2, the cavity it forms; 3, its lower front edge, which is attached to the upper ring of the trachea; 4, the articular surface for the arytenoid.

Fig. 143, posterior view of left arytenoid cartilage; 1, its surface; 2, its summit; 4, external, and 5, internal angle; 3, articulating surface for the cricoid.

Fig. 144, anterior view of 143.

Fig. 145, lateral view of thyroid; 1, body; 2, inner surface; 3, superior border; 4, anterior notch; 5, anterior surface; 6, tubercle; 7, posterior border; 8, superior, 9, inferior horn.

Fig. 146, front view of 145.

Fig. 147, Epiglottis; 1, superior, 2, inferior surface; 3, superior, posterior, and 4, anterior and inferior extremity; 5, 5, its sides. It is situated above the opening into the larynx, and so as to close it when the rest of the larynx is raised against the epiglottis. See fig. 2 pi. 6. The tongue is also connected to this sort of valve, and when the tongue is thrust out or drawn forward, the epiglottis will be raised also, which is a fact of great importance in case of drowning.

Fig. 148, front view of hyoid bone; 1 body; 2 major, 3, minor horns.

Fig. 148,* represents a view from above of the vocal cord 3, 3, and 1, a space between, through which the air passes. 3, thyroid, 9, cricoid, 2 arytenoid cartilages; 4, 5, 6 and 7, muscles of the larynx.

Fig. 140.

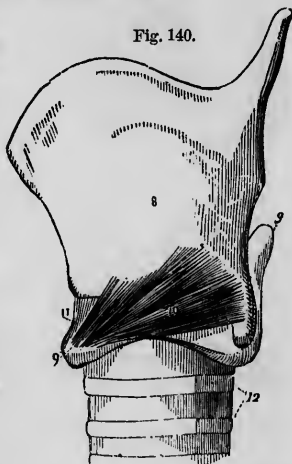
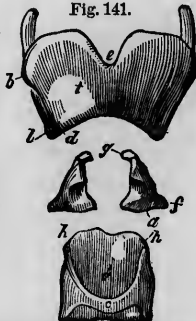


Fig. 141.



409. The various parts of the larynx form a kind of box, and by moving upon each other, they regulate the cavity within, the orifice through which the air passes out, and the tensivity of the vocal cords, between the edges of which it passes.

Fig. 142.

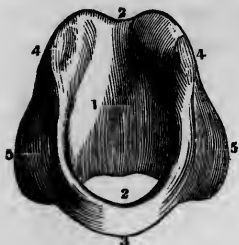


Fig. 143.



Fig. 144.



Fig. 145.

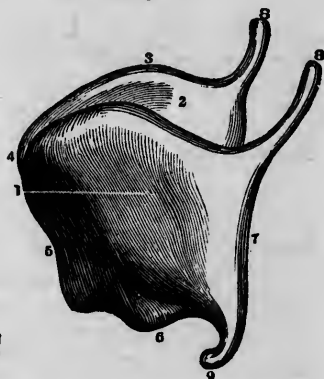


Fig. 146.

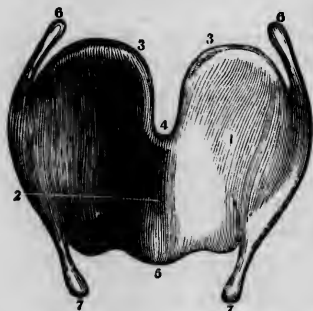


Fig. 147.



Fig. 148.

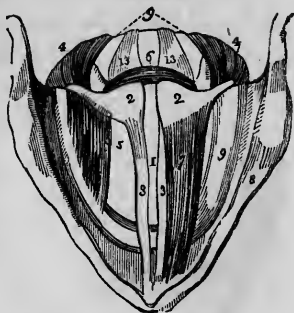


Describe figs. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. What do the various parts of the larynx form? What is their use?

410. The *essential requisites for the easy and healthy production of voice*, are exercise, and freedom from restraint.

Any constrained position, or constricting clothing, is prejudicial. A drooped position of the head, tight neck bands, the shoulders held back, or in any particular position, the waist tightly dressed, injure the action of the speaking apparatus.

Fig. 148.*



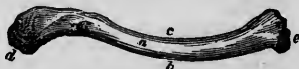
Skeleton of the handling Apparatus, or Upper or Thoracic Extremities.

411. The *skeleton of the handling apparatus* includes that of the shoulder, upper and lower arms, and the hand.

412. The *skeleton of the shoulder* includes the clavicle, scapula, their joints, &c.

413. The *clavicle* or collar-bone, is a slender, somewhat flattened bone, of medium size, doubly curved. Within it

Fig. 149.—Clavicle. *a*, Body. *c*, Inner or concave. *b*, Outer or convex border. *d*, Acromial, *e*, Sternal end.



a medullary canal of small size is found. It is situated in front of the uppermost part of the chest, by one extremity being articulated by a movable joint to the sternum, while the rest of the bone stretches out towards the tip of the shoulder.

It may be considered as a radius of a sphere of which the sternum is the centre; the outer end describes the surface—or it may be considered as a lever, the sternal end resting as a pivot upon the sternum as a fulcrum—or it may be likened to a crane, by which articles are swept around from one position to another—or again it may be called a brace. Its position and proper use should be well appreciated. Cruvelhier says that more than any bone it exhibits

What are the requisites for proper production of voice? What injures the voice? What does the skeleton of the handling apparatus include? What does the skeleton of the shoulder include? Describe the clavicle?

the effect of manual labor, and that he has many times detected left-handed persons by the greater comparative size of the left clavicle. It differs in length and size naturally in case of males and females being compared, and this is one reason why sweeping floors, and all labor requiring leverage, is so tedious for women, but easy for men, while taking care of children is easiest for women.

Fig. 150.

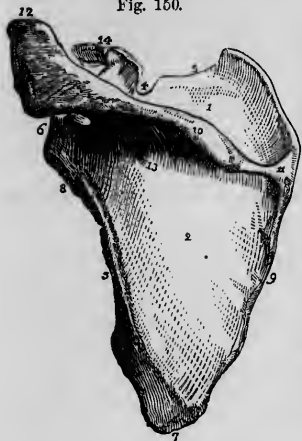


Fig. 150. Back view of scapula. 1. Supra-spinous fossa. 2. Infra-spinous fossa. 3. Superior border. 4. Notch. 5. Inferior border. 6. Head and glenoid cavity. 7. Inferior angle. 8. Neck. 9. Base of the scapula. 10. The spine. 11. Smooth surface. 12. Acromion process. 13. Foramen. 14. Coracoid process.

414. The *scapula* presents for our consideration, a socket, body, spine, and acromion and coracoid processes.

415. The *socket* is the essential part of the bone, as to this the arm is attached, and the other parts of the scapula are for the purpose of guiding the motions of the socket, and by that means the motions of the arm. Little need however be said, as the eye reads the socket clearly by the various cuts of it, which see.

416. The *body of the scapula*, is a very thin plate of bone, the shape of which is readily seen and its size felt. The circumference is somewhat thickened, to give it strength. The body presents two surfaces. The under surface is somewhat concave, the degree of its concavity differing in different persons. By this shape it is fitted to the natural and proper form of the chest, upon which it is placed, and to which, so to speak, it is moulded.

Inf. When the form of the chest is altered the scapula can no longer be adapted to its place, but must project in some unseemly way.

What kinds of labor are comparatively easier for men than women? What parts have we to consider in the scapula? Which is the most essential part of the scapula? What is the body of the scapula? How is it fitted to the surface of the chest?

417. The *outer surface of the scapula* is divided by the spine into the supra and infra spinous surfaces, which offer nothing worthy of note here. The spine rises at the back part of the scapula, and gradually becomes that very prominent ridge that may be so distinctly felt. This terminates in a prominence above the socket, and shielding it, called the acromion process. To this the clavicle is articulated. The coracoid process springs out from the scapula near the socket, and serves for the attachment of muscles.

The shoulder considered generally.

418. The *scapulæ* or shoulder blades are not jointed or articulated upon the ribs, but to the clavicles alone.

The object of this is to throw out the joints to a distance from the ribs, and give to the arms greater sweep of motion, as well as to the muscles greater leverage. The flat bodies of the scapulæ are merely broad processes, for the attachment of muscles, that through them move the shoulder socket. These muscles lie, in part, between the bodies and the ribs, forming in fact a kind of cushion for the shoulder blades.

419. The *position of the scapulæ* cannot, therefore, affect the absolute size of the chest.

It is thought to do so, because when the shoulders are thrown back more of the chest appears in front; but it has diminished behind correspondingly. Besides, if the chest was thus made *permanently* larger, it would be an injury, for as before shown, it is desirable to have the chest alternately large and small; to wit, extensively movable; for this purpose, as shown, there must be no fixedness of any part, but freedom from restraint, and development of motion by proper exercise.

420. *Form of shoulders.* This is one of the most important points that physiology discusses. Form of the shoulders depends upon natural constitution, age, health; but chiefly upon the dress and exercise, or want of it.

What is the spine of the scapula? What is the acromion process? What is the coracoid process? To what are the scapulæ jointed? Is the size of the chest affected by the position of the scapulæ? Why is it thought that they do affect it?

If the dress be tight about the waist, the dorsal discs will be compressed, and the column curved forward accordingly; this throws the head forward and downward; to correct the last inconvenience the neck is bent backward, which causes unnatural constriction of the vocal organs. But the head yet projects, and this causes the shoulders to appear as if projecting, when they are not perhaps as far back as they should be. The form of the chest being changed, the edges and angles of the shoulder blades present themselves unseemly. The natural curvature to the right, the liver upon the right side, and the unyielding character of the right compared with the left side in a downward direction, causes a real prominence of the upper part of the right chest; but since the left is depressed, the right shoulder will appear much the most prominent.

421. *The real cause of prominence or deformity of the right shoulder is to be chiefly attributed to compressing the chest, suspending clothing upon it, to the use of whalebones, and to sedentary habits.*

If this be not so, why is not the right shoulder as prominent in case of men as in case of women? I know it will be said, "I never did dress tightly." But persons merely mistake. Tight dress is used upon the little girl, till she becomes accustomed to it, and does not know what a tight or loose dress is. Beauty of person, or loveliness of mind, can never be possessed to the highest degree of which ladies are capable, till the obnoxious custom of tightly (only snugly?) dressing is laid aside, and from infancy up, the whole system is allowed free motion. The clothing must likewise be suspended by straps, or still better by a waist upon the shoulders. The exhausting effect of the weight of ordinary clothing would be too much for the stoutest man, and of course not a little of the ill health, deformity, and the want of beauty of complexion, and vivacity of mind among females, may be attributed to this ordinary custom.

A most unfortunate fashion has been introduced among men, of laying aside suspenders. The tightness with which the clothing must then be worn, as well as even its light weight, are very prejudicial to health and form.

Another cause of bad shoulders among females is, wearing dresses low about the neck, or perhaps even off the shoulder. This is more likely to be the case with children. This causes the

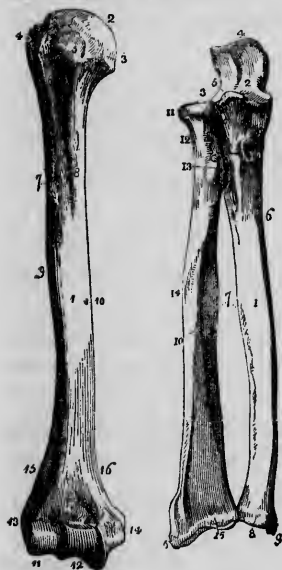
What effect upon the shoulders is produced by constricting the chest? How? Causes of deformity of the right shoulder? How can ladies be rendered more beautiful and attractive than they even now are? Effect of not wearing suspenders?

shoulders to become "shrugged," it confines the motions of the chest, and of course causes deformity of it and the shoulders, besides making the motions of a person awkward and stiff.*

422. To *correct and prevent deformities of the shoulder*, the clothing must be free, the position of all parts unrestrained, and plenty of various kinds of exercise taken.

Upper and Lower Arms.

Figs. 151* and 152.†



* The humerus of the right side; its anterior surface. 1. The shaft of the bone. 2. The head. 3. The anatomical neck. 4. The greater tuberosity. 5. The lesser tuberosity. 6. The bicipital groove. 7. The anterior bicipital ridge. 8. The posterior bicipital ridge. 9. The rough surface into which the deltoid is inserted. 10. The nutritious foramen. 11. The rounded protuberance of the articular surface. 12. The pulley-like surface. 13. The external condyle. 14. The internal condyle. 15. The external condyloid ridge. 16. The internal condyloid ridge. 17. The fossa for the coronoid process of the ulna.

† The two bones of the fore-arm seen from the front. 1. The shaft of the ulna. 2. The greater sigmoid notch. 3. The lesser sigmoid notch, with which the head of the radius is articulated. 4. The olecranon process. 5. The coronoid process. 6. The nutritious foramen. 7. The sharp ridges upon the two bones to which the interosseous membrane is attached. 8. The rounded head at the lower extremity of the ulna. 9. The styloid process. 10. The shaft of the radius. 11. Its head, surrounded by the smooth border for articulation with the orbicular ligament. 12. The neck of the radius. 13. Its tuberosity. 14. The oblique line. 15. The lower extremity of the bone. 16. Its styloid process.

423. The *skeleton* of the *upper arm* includes but one bone, the description of which

* The reason why the dress is worn low, viz., to render a person more attractive, is to me the very reason why it should be reasonably high. For there is not one in a thousand whose arm or neck is so well formed, or with complexion so fine, that it is any credit to expose them; and, in the next place, there is nothing which renders woman so attractive as the most refined modesty, and there is nothing so repugnant as the least want, or appearance of the want of it. Imported fashions and manners

Effect of low dresses in producing deformity? How correct deformities of the shoulders? Describe figs. 151, 152. How many bones in the upper arm?

is well enough made by fig. 151. At the back part of the lower end of the bone, a deep fossa exists to receive the olecranon process of the ulna and restrict motion in a backward direction; indeed the two arms cannot be brought into the same line.

424. The *skeleton* of the *lower arm* embraces two bones, the form, size, and proportions of which are at once described by fig. 152. They reach from the elbow to the wrist. One only, the ulna, assists in forming the elbow joint, while to the radius only the wrist is attached.

425. The *connections* between the two bones are peculiar. A ligament called interosseous extends between them, from the bottom nearly to the top of the space intervening between them, while two movable joints are found at their points of contact.

426. The *mechanism* of the motions of the radius is very simple, but usually confused by the use of wrong terms. There are two different kinds of joints.

427. The *lower joint* is a *hinge*, and the motion allowed by it is the same as that of a book lid when the other part is held fast, and if a hand should extend from the book lid, it could be made prone and supine by simply opening and shutting the lid. If to the open lid a rod, a foot or more in length,

make us forget sometimes that words do not always mean the same in the Old World and New. There, where vice walks abroad in daylight, a person may be called and thought a lady, let her dress be what it may, if only fashionable; but it is the exceptionless and exalted opinion of American gentlemen (and I speak upon the authority of all classes), that lady, means a person too sensitive to appear in public with short sleeves or a dress low about the neck. I know ladies are not aware of this, but could they hear the remarks which are *always* made on such modes of dress, it would never be seen in any circles of well bred people.

It might by some be expected that leaning upon the elbow would be mentioned as a cause of deformity. It has been, to be sure, said to be, but there is not a shadow of reason for truth in the statement. Is not the left elbow leaned upon more than the right? Does it not first receive a patch, as a general thing? Do not men and boys lean upon the elbow as much as ladies and girls? The idea is merely ridiculous.

What is noticeable at the lower back part of the humerus? How many bones in the lower arm? What is the interosseous ligament of the fore-arm? Of what kind is the lower joint of the fore-arm? The motion by its means, is compared with what?

be fastened near the hinge, and the end farthest from the book be held in the hand, motionless as far as possible, the motion of the upper part of the radius will be perceived when the lid is opened and closed. If another rod be fastened to the body of the book near the hinge, and the hands be placed side by side, the motion will be more perfectly exhibited.

The only difficulty to obviate in this experiment is, that the hinge of the book is long, and the whole length of the rods will turn at once, except one is rather loosely fastened to the cover. It will be noticed that the hinge point of the bones is very small. If the bones be at hand, they can be fastened by a hinge very narrow and somewhat loose in its joint, and thus experiment the motion perfectly.

428. The *upper joint* is one of semi-rotation, though the motions are somewhat of an oblique character.

429. The *lower arm bones are often fractured*, and when this is the case with either of them, the arm very seldom regains its perfect form, owing to the action of the muscles in displacing the bones, and the inattention of people in observing the directions which are given to them: they not being aware of their importance.

The Hand.

That learned English author, Sir Charles Bell, did well to devote an entire volume to this truly wonderful piece of mechanism. No other part of the body proves more conclusively than this that man possesses a mind, since it is needed to use the hand to the full extent of its adaptation. The corresponding part in other animals is a modification of the hand, but never with any additions. Its most singular modifications are seen in the bat and bird. In both cases, wings being formed by the upper extremities, but of an entirely different character from each other. The field of Natural History is full of similar illustrations of the resources of the Divine Mind; space, however, does not permit me to enter into a particular description of the hand.

If a skeleton of a hand were fastened to a book lid, when would the hand be prone and supine? Will you try the experiment with rods and book lid, cutting a piece of pasteboard to resemble a hand, or drawing the surfaces of a hand upon opposite sides of a book lid?

430. The *hand* is constructed of six ranks of bones. 1st. The first includes the pisiform and the three bones which articulate with the radius. The three together are seen to form a kind of head which rolls in the socket of the radius. 2d. The second rank includes the remaining four bones of the carpus, which is thus formed in order to combine soli-



Fig. 153.

Fig. 153, skeleton of bat, and outline of membranous wings; *o*, scapula; *cl*, clavicle; *h*, humerus; *cu*, ulna; *r*, radius; *ca*, carpus; *po*, thumb; *ph*, phalanges; *f*, femur; *ti*, tibia.

Fig. 154.



Fig. 154, skeleton of bird; *cv*, cervical vertebra; *cl*, clavicles; *ca*, carpus; *ph*, phalanges; *st*, sternum; *ti*, tibia; *ta*, tarsus; *cr*, fore arm; *h*, humerus; *sv*, sacral vertebrae; *f*, femur; *ca. v*, caudal vertebrae.

Who is the most elegant writer upon the hand? Why does it prove the existence of a mind? Of how many ranks of bones is it composed? Which bones does the first rank include? What does the second rank include? Describe figs. 153, 154.

dity with elasticity to the highest degree. 3d. The third rank includes the five metacarpal pillars, upon the outer shallow socketed extremities of which rest. 4th. The third rank, including five bones, the first of the fingers and thumb. 5th. The fifth rank includes the four middle bones of the fingers, none being present in the thumb. 6th. The sixth rank includes the five terminal bones of the fingers and thumb. The first bone of a finger is called phalange; the second, phalange; and the last, phalangette—the three a phalanx; and those of all the fingers and thumb are called phalanges.

* A diagram showing the dorsal surface of the bones of the carpus, with their articulations. —The right hand. R. The lower end of the radius. U. The lower extremity of the ulna. F. The inter-articular fibro-cartilage attached to the styloid process of the ulna, and to the margin of the articular surface of the radius. S. The scaphoid bone: the numeral (5) indicates the number of bones with which it articulates. L. The semilunar, articulating with five bones. C. The cuneiform, articulating with three bones. P. The pisiform, articulating with the cuneiform only. T. The first bone of the second row—the trapezium, articulating with four bones. T. The second bone—the trapezoid, articulating also with four bones. M. The os magnum, articulating with seven. U. The unciform, articulating with five. The numerals, 1, 3, 1, 2, 1, on the metacarpal bones, refer to the number of their articulations with the carpal bones.

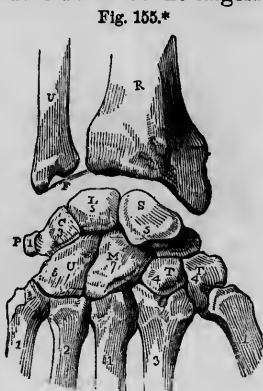


Fig. 155.*

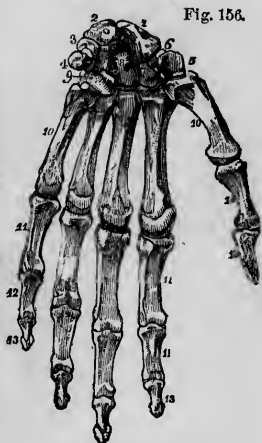


Fig. 156.

Fig. 156. The hand viewed upon its anterior or palmar aspect. 1. The scaphoid bone. 2. The semilunar. 3. The cuneiform. 4. The pisiform. 5. The trapezium. 6. The groove in the trapezium that lodges the tendon of the flexor carpi radialis. 7. The trapezoid. 8. The os magnum. 9. The unciform. 10, 10. The five metacarpal bones. 11, 11. The first row of phalanges. 12, 12. The second row. 13, 13. The third row, or ungual phalanges. 14. The first phalanx of the thumb. 15. The second and last phalanx of the thumb.

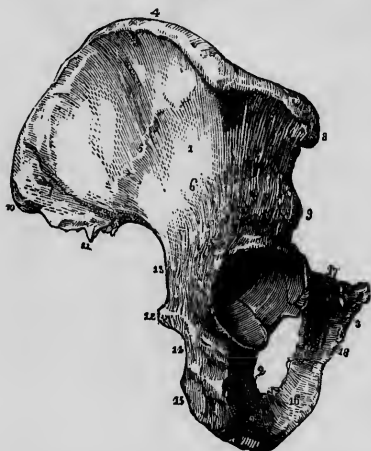
What does the 3d rank include? 4th? 5th? 6th? Describe figs. 155, 156.

431. From another point of view, the hand may be considered as *composed of a series of levers*, radiating from a common centre, by which arrangement they can be brought to clasp, or pinch any thing which it is desirable to examine or move; and thus the hand becomes a very handy instrument.

432. The *motions of the hand are produced* by the motions of, 1st, the body upon the feet; 2d, the knee joint; 3d, the trunk upon the thighs; 4th, the vertebræ upon each other; 5th, the elevated and depressed chest; 6th, the shoulder bone; 7th, the rotating humerus; 8th, the elbow joint; 9th, the turning radius; 10th, the wrist joint. Thus it can be swept through a great extent of space, and also made to visit every part of the body.

Skeleton of Locomotive Apparatus—the Lower, or Abdominal Extremities.

Fig. 157.



433. The *skeleton of the locomotive apparatus* is constructed of the hip, thigh, lower leg, and foot bones.

Fig. 157. The os innominatum of the right side. 1. The ilium; its external surface. 2. The ischium. 3. The os pubis. 4. The crest of the ilium. 5. The superior curved line. 6. The inferior curved line. 7. The surface for the gluteus maximus. 8. The anterior superior spinous process. 9. The anterior inferior spinous process. 10. The posterior superior spinous process. 11. The posterior inferior spinous process. 12. The spine of the ischium. 13. The great sacro-sciatic notch. 14. The lesser sacro-sciatic notch. 15. The tuberosity of the ischium, showing its three facets. 16. The ramus of the ischium. 17. The body of the os pubis. 18. The ramus of the pubis.

Why may the fingers be called levers? What produces the motions of the hand?

Ossa Innominata.

434. The *hip bones* are called *ossa innominata*. They are the largest broad bones in the body. Their form is very irregular, and their surface very rough. They are jointed to each other in front, forming the symphysis pubis. They are firmly locked to each side of the sacrum, which in two directions is wedged between.—They, with the sacrum complete the kind of bony circle called the pelvis.

Fig. 158.

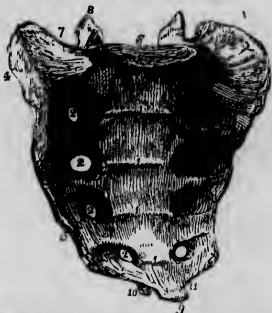
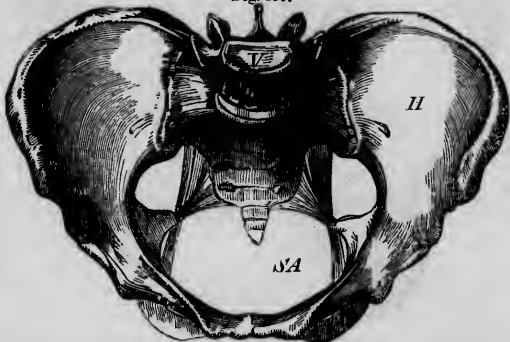


Fig. 159.



435. The *external and internal* surfaces of the pelvis do not correspond with each other. The external is adapted to receive the head of the thigh bone in its socket, denominated the acetabulum, and to allow the attachment of the muscles

Fig. 158. The sacrum seen upon its anterior surface. 1, 1. The transverse lines marking the original constitution of the bone of the four pieces. 2, 2. The anterior sacral foramina. 3. The promontory of the sacrum. 4. The ear-shaped surface which articulates with the ilium. 5. The sharp edge to which the sacro-ischial ligaments are attached. 6. The vertebral articular surface. 7. The broad triangular surface which supports the psoas muscle and lumbo-sacral nerve. 8. The articular process of the right side. 9. The inferior extremity, or apex of the sacrum. 10. One of the sacral cornua. 11. The notch which is converted into a foramen by the coccyx.

What is the common name of the ossa innominata? Where are they situated? What is the pelvis? Do its surfaces correspond?

appropriate to moving the thigh. The internal is adapted to lodge, support, and protect the pelvic viscera. There is, therefore, if the expression may be allowed, a double pelvis to be noticed, one of which is placed within the other; viz., the two laminæ of the pelvic bones, the irregular space between the two being filled with cancellated bone, the cancelli of which are filled with marrow. These two laminæ may therefore be called, one the abdominal, the other the locomotive pelvis.

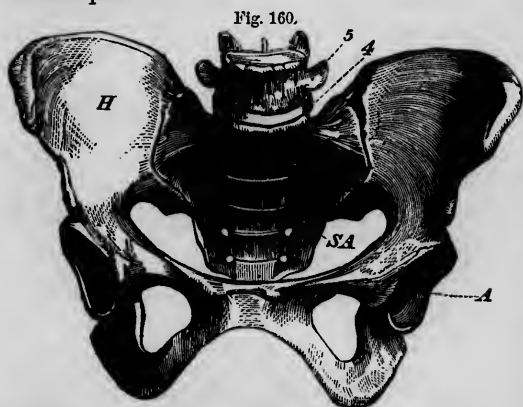


Fig. 159.
Front view
of the pelvis
from above.
V Lower
lumbar ver-
tebra. S, A.
sacrum, ter-
minated by
the coccyx.
H. Os inno-
minatum.

Fig. 160.
Pelvis. 5.
Lower lum-
bar / verte-
bra. 4. In-
ter-verte-

bral substance, in this case, between the vertebra and sacrum. S, A. Sacrum. H. Os innominatum. A. Acetabulum.

436. The *uses of the pelvis* are therefore threefold: 1st. Locomotive. 2d. Abdominal. 3d. By its very irregular form, and cancellated, medullary character, it disperses much of the jar received from the thigh bone, and communicates but little of it to the sacrum.

The holes seen in front of the pelvis make the bones lighter, while they do not weaken them.

To what purposes is the external surface of the pelvis adapted? To what the internal? Why may the pelvis be called double? Describe fig. 159, and fig. 160. What are the uses of the pelvis?

Femur.

437. The *femur* is divided into the head, neck, trochanters, body or shaft, and the condyles. The *head* forms rather more than half a sphere, and is perfectly adapted to the socket, so that, though it will turn in it with the greatest ease, about forty to fifty pounds' weight is necessary to draw it from its place when all the external ligaments are removed. A slight depression is found at the centre of the spherical surface, which furnishes attachment to one end of a short round ligament, which by the other end is attached to a corresponding depression a little to one side of the centre of the socket. This ligament

Fig. 161.



Fig. 162.

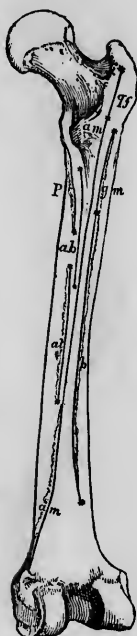


Fig. 161.—The right femur, seen upon the anterior aspect. 1. The shaft. 2. The head. 3. The neck. 4. The great trochanter. 5. The anterior intertrochanteric line. 6. The lesser trochanter. 7. The external condyle. 8. The internal condyle. 9. The tuberosity for the attachment of the external lateral ligaments. 10. The groove for the tendon of origin of the popliteus muscle. 11. The tuberosity for the attachment of the internal lateral ligament.

Fig. 162.—A diagram of the posterior aspect of the right femur, showing the lines of attachment of the muscles. The muscles attached to the inner lip are,—*p*, the pectineus; *a b*, the adductor brevis; and *a l*, the adductor longus. The middle portion is occupied for its whole extent by *a m*, the adductor magnus; and is continuous superiorly with *g f*, the linea quadrati, into which the quadratus femoris is inserted. The outer lip is occupied by *g m*, the gluteus maximus; and *b*, the short head of the biceps.

Into what parts is the femur divisible? Describe the head of femur? What and where is the round ligament? Describe figs. 161, 162.

Fig. 163.



has no use in ordinary motion of the thigh, but checks extraordinary movement. The *neck* connects, by a very obtuse angle, the head to the body. The peculiar form of the neck is very admirable, strength being conferred by a very slight expenditure of material. The uses of the neck are, to throw the weight of the parts above to a farther distance from the centre of gravity, to give free motion to the thigh, to allow the muscles of the hips to act upon the thigh more favorably, and to disperse the jar received from the body of the femur. The *trochanters* serve for the attachment and more powerful action of muscles. The body of the bone is curved from the front backward, or is slightly convex in front,* and somewhat twisted. The peculiar reason for the twist has not been perceived. The condyles are two, called the external and internal. By their large size, they assist in

forming a very secure joint at the knee.

438. The *knee joint* is one of the most perfect hinges in

Fig. 163.—The tibia and fibula of the right leg, articulated and seen from the front. 1. The shaft of the tibia. 2. The inner tuberosity. 3. The outer tuberosity. 4. The spinous process. 5. The tubercle. 6. The internal or subcutaneous surface of the shaft. 7. The lower extremity of the tibia. 8. The internal malleolus. 9. The shaft of the fibula. 10. Its upper extremity. 11. Its lower extremity, the external malleolus.

* Some have supposed that this convex form of the bone was produced by the weight of the foot and lower leg, and therefore recommend that children should have low seats, and touch the floor with their feet. There is no doubt about the value of this injunction; but if the weight of the feet can bend the thigh bone, what will be the effect of jumping, walking, or even standing? The idea is simply ridiculous. The femur is *always* curved to give it strength.

How is the neck of the femur constructed? What is its use? What is the use of the trochanters? What is there peculiar in the body of the femur? Where are the condyles of the femur? Of what kind is the knee-joint?

the body. The incrustation of cartilage is thick; two inter-articular cartilages, called, from their form, semilunar, also exist. At this joint the kneepan, patella, or rotula is also found. It belongs to the class of sesamoid bones, several of which exist at the smaller joints of the hand and foot. They are usually very small, but the patella is large. Its use is, to facilitate the motion of the tendon of the muscles which act upon the front and upper extremity of the tibia below. It also removes the action farther from a direct line, and therefore serves at the same time the purpose of a lever and a fulcrum.

439. The *lower leg* exhibits two bones, the larger called the tibia, and the smaller the fibula. The tibia is very large above, and alone, of the leg bones, assists in forming the knee-joint. Its form is triangular, one angle being in front, as most persons have had cause to know. The fibula is a slender, long bone, united above to the tibia by a scarcely movable joint, and throughout its length by an interosseous ligament. Thus, with small expenditure of material, great strength and great extent of surface, for the attachment of the numerous muscles which act upon the foot, with lightness, is gained. At the lower extremities of both bones, processes, called the malleoli, are seen. They guard the ankle joint.

440. The *foot* is constructed of the tarsus or ankle; metatarsus or pre-ankle, and the toes. The ankle is constructed of seven bones, with thin cartilages, synovial capsules, and ligaments, forming a strong, firm, and yet elastic piece of mechanism. The metatarsus is composed of five bones curiously locked together with the tarsus. It should be observed that they do not unite with the tarsus on a line.

What are the peculiarities of the knee joint? What is the use of the sesamoid bones? How many bones in the lower leg? What are the malleolar processes?

The bones of the toes are three in number in the middle three; two in the great toe; sometimes three, and sometimes two in the small toe.



Fig. 164.

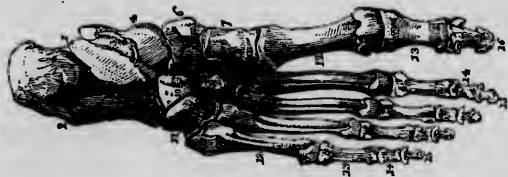


Fig. 165.

Fig. 166.



Fig. 166.—*a*, Articulating surface of astragalus. *b*, Its anterior extremity. *c*, Body. *d*, Inferior posterior; and *e*, anterior part of os calcis. *g*, Scaphoid. *f*, Cuneiform. *m*, Metatarsus. *s*, Inferior tuberosity. *n*, Phalanges.

Fig. 164.—The dorsal surface of the left foot. 1. The astragalus; its superior quadrilateral articular surface. 2. The anterior extremity of the astragalus; which articulates with (4.) the scaphoid bone. 3. The os calcis. 4. The scaphoid bone. 5. The internal cuneiform bone. 6. The middle cuneiform bone. 7. The external cuneiform bone. 8. The cuboid bone. 9. The metatarsal bones of the first and second toes. 10. The first phalanx of the great toe. 11. The second phalanx of the great toe. 12. The first phalanx of the second toe. 13. Its second phalanx. 14. Its third phalanx.

Fig. 165.—The sole of the left foot. 1. The inner tuberosity of the os calcis. 2. The outer tuberosity. 3. The groove for the tendon of the flexor longus digitorum. 4. The rounded head of the astragalus. 5. The scaphoid bone. 6. Its tuberosity. 7. The internal cuneiform bone; its broad extremity. 8. The middle cuneiform bone. 9. The external cuneiform bone. 10, 11. The cuboid bone. 11 Refers to the groove for the tendon of the peroneus longus. 12, 12. The metatarsal bones. 13, 13. The first phalanges. 14, 14. The second phalanges of the four lesser toes. 15, 15. The third, or ungual phalanges of the four lesser toes. 16. The last phalanx of the great toe.

Of what parts is the foot constructed? How many bones in the ankle? What fig. represents a section of the bones, capsules, &c., of the foot? Describe figs. 164, 165, 166.

to gather knowledge, be led to obtain it by observation in the fields of nature, not too much from books which may in a sedentary manner be perused. It is useless to say to the mind that loves to learn, “you will be injured, take muscular exercise.” It will read, except it be equally or better satisfied. It is an appetite, which may be satisfied in the way indicated without harm, and the results will be every way good.

444. But the *body is a republic*, and while the skeleton serves the other parts, they must serve it. The stomach must receive and properly digest food, wholesome for the skeleton, the lungs must breathe a large quantity of pure air, the heart must fulfil its duties, the skin and kidneys must excrete. Then with a proper natural constitution, and exercise, day by day, there will be a harmonious adaptation of the skeleton to all the ages of life through which man passes, from the flexible and elastic skeleton of infancy, to the rigid framework adapted to old age.

CHAPTER II.

Muscular System.

Tendons—Aponeuroses—Ligaments—Areolar Tissues—Bursæ—Fat.

ANALYSIS.—*Molecular, Ciliary, Elastic, and Muscular motion—Denominative names, size, number, form, axis of direction, attachments, and uses of muscles—Muscles of relative and organic life—mixed muscles—Anatomical grouping of muscles—1st, of the head; 2d, neck; 3d, trunk; 4th, upper, and 5th, lower extremities—Physiological classification, a the cutaneous, b those of organs of sense, c those which move and stay the head and spinal column, d those of speech, e of the upper extremities, f of the lower extremities—view of living muscular system.*

General Remarks.

445. *Four kinds of motion* may be observed in the Human Body—Molecular, Ciliary, Elastic, and Muscular.

Upon what does the flow of blood to the bones depend? How can the bony system be developed? How may an appetite for knowledge be profitably satisfied? What things are essential to a perfect skeleton?

446. *Molecular motion.* If almost any of the fluids of the body be examined beneath a powerful microscope, molecules will be seen darting with great rapidity from one place to another; or moving more leisurly without apparent cause, and as if spontaneously. It is, however, supposed that these motions are produced by unequal temperatures, or by chemical attractions.

447. *Ciliary motion.* Beneath the microscope the epithelial cells of certain membranes are seen to be provided with processes, which from their formal resemblance to the hairs of the eye-brow, are called cilia, (see fig.) In certain animals such cilia have a rotatory motion; in man they move backward and forward with great velocity. The use of their motion is, to move the fluids over the surfaces where they are in one direction. Their motion continues some time after general death, and after the cells are removed from their supporting membrane. The motion must therefore depend upon some property inherent in the cell, or the ciliated part of it; but how it is produced is not at present understood.

448. *The motion of elasticity* is always in response to some force which has disturbed the part exhibiting it. The elastic character of certain tissues seems to have been given for the purpose of causing them to maintain their ordinary positions without the expenditure of muscular power. It is also not a little useful for the purpose of restoring the parts where it exists to their natural positions, and is then actively exhibited.

449. *Muscular contractility* is the cause of by far the greater part of the motions exhibited in the body, and of all those which are subject to the will.

What is molecular motion? What is the supposed cause of it? What is the cause of ciliary motion? What is the use of it? What is the motion of elasticity? What is muscular contractility?

General Character of Muscles.

Muscle is the proper name of what is ordinarily called lean meat. In the ordinary acceptation of the term, it includes more than muscular tissue. The distinguishing characteristics of this is, that it is composed almost or entirely of fibrin, and possesses the power of contractility. The muscle being a bundle of fasciculated fibrils, includes the tissue, and the fibrous sheaths, areolar tissue, tendons, and aponeurosis, as well as blood-vessels, lymphatics, and nerves connected therewith. Using the term in its ordinary sense, a muscle is therefore composed of fibrin, albumen, and gelatin.

The *names* of muscles have been given to them on account of, 1st, size: as, major, minor, &c.; 2d, form: as, pyramidalis, deltoid, &c.; 3d, direction: as, rectus, oblique, &c.; 4th, number of parts exhibited: as, biceps, digastricus, &c.; 5th, situation: as, radialis, &c.; 6th, parts with which they are connected: as, sterno-clydo-mastoid, &c.; 7th, uses: as, extensor, pronator, &c.

The size of a muscle depends upon the number and size of the lacerti or fasciculi forming it, which vary very much, according to the use to which the muscle is to be applied. Nominally the size of a muscle will depend upon the arrangement of the fasciculi. Each fasciculus might be called a muscle; but when a number of fasciculi are surrounded by a common sheath, and attached by a distinct tendon to the part to be acted upon, or when a group of fasciculi, are distinctly connected by a tendon with the part to be moved, and toward the same end enveloped for part of their length with a sheath, though in a common sheath with other bundles, for the rest of their length, a muscle is formed.

The *number* of muscles has been variously computed by different authors for want of some rule, such as the one just mentioned, and because different muscles are many times so blended, that it is difficult, accurately, to distinguish them. The number will not be less than four hundred, according to a proper mode of distinguishing them.

The *form* of the muscles varies almost with every pair of them. They are, however, classed as the long, short, and broad. The length of the muscle depends frequently, for the most part, upon its tendon. They usually extend over several articulations, and can, therefore, assist in moving several parts. The short muscles mostly exist in the vicinity of the short bones. The broad muscles usually assist in forming the walls of cavities, and are quadrilateral, triangular, and arched. The first exist entirely upon the trunk, the second extend from the trunk to the extremities, the third is found only in the diaphragm.

Direction of muscles. 1st. The line of direction in which a muscle acts is called its axis. Sometimes the fasciculi of a muscle are paral-

What does the term muscle in ordinary acceptation include? From what have muscles been named? Upon what does the size of a muscle depend? How many muscles? What division of muscles depending upon their form has been made.

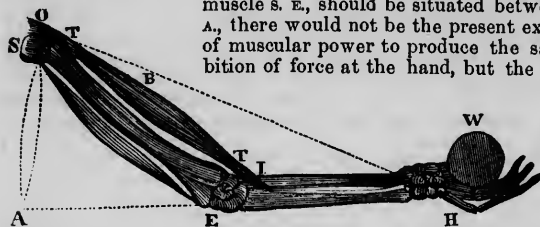
lel to it, but usually they are oblique to it. This renders it necessary that every one should vary in length; and the precision with which they are adapted to their position relative to the axis of direction, is one of the most wonderful things in the body, or in nature, especially if it is considered that the growth of all parts of the muscle must be, and is, so nicely balanced as to always maintain their necessary relation. 2d. Sometimes the axis of a muscle's action is either perpendicular to the lever, or in a direct line with the motion produced, but usually the muscle acts obliquely, and the degree of its obliquity is constantly changing. The number, arrangement, and length of its fasciculi must be adapted to the case. Sometimes the direction of the motion produced by a muscle is dependent on the tendon, which is curved round some point serving for a pulley. In this case the action of the muscular part is, with very few exceptions, direct.

Attachments of muscles. The attachment of muscular to fibrous tissue was considered in Part II. Some of the muscles have no tendons, their fasciculi forming rings, as in the sphincters of the mouth, &c; see Plate 2 or 7. Most, however, have tendons; the fibres of some blending with those of the skin, cause their muscles to be called cutaneous; e. g., some of those of the face and head. The tendinous fibres of some muscles intermingle with the fibrous tissue of other muscles, as is distinctly seen in the face. Most of the tendons, however, serve to attach their muscles to the bones and cartilages, the tendinous fibres being blended, and becoming continuous with the fibres of the periosteum and chondrium, by which arrangement the extent of bony surface required for the attachment of muscles is very much economized, and their action brought to bear upon almost a single point. The attachment, which is usually fixed, is called the origin, and the point usually moved the insertion of a muscle, as seen at o, i, fig. 167.

The *uses* of muscles are to exert force and produce rapid motion. The first depends upon their size and the axis of their action, compared with the direction of the desirable motion. The second depends upon their length and arrangement. Usually the *exhibition* of great force, has been sacrificed to rapidity of motion, though the *exertion* of great force in the production of the motion is necessary. e. g., The muscle upon the front part of the upper arm is attached to the bones of the lower arm near the elbow joint, so that as it requires much force, applied near the hinge, to shut a door or gate, so is much power required to raise the fore-arm, compared with what would be if a muscle acted upward at right angles to the outer end of the fore-arm or lever, or if the muscle should act in the line t. n. fig. 167 there would be less force required than at present. Or if to produce the opposite motion of the hand, the ulnar bone should extend past

What is the axis of a muscle? Are the fasciculi of a muscle similar in length? Is the axis of a muscle always perpendicular to the motion caused? To what parts are muscles attached?

Fig. 167.



the elbow in the line E. A., and the triceps muscle S. E., should be situated between S. and A., there would not be the present expenditure of muscular power to produce the same exhibition of force at the hand, but the extent of

motion would be much less in the same time. For if the muscles T. H. or S. H. should contract an inch, they would move the hand but about an inch, while if the muscles T. I. or S. E. contract an inch, they will move the hand through an extensive sweep, and it will require no more time for the muscles to contract an inch, in one case, than in the other; but the muscles exert about twenty times the power in one case that they would in the other.

Classification of Muscles.

450. The *muscles* may be divided into those of *relation*, or voluntary, those of *organic life*, or the involuntary and the *mixed*. The first two expressions need no explanation. The mixed include those which usually act involuntarily, but can be controlled by an effort of the will; these are the muscles of respiration engaged in speech, and the muscles of expression. They properly belong with those of relation, which are to be described in this chapter, those of organic life being most properly described with the organs to which they belong, it being hardly proper to call them organs, as we should those of relation.

451. The *muscles of relation* are either in pairs, or if apparently single, are composed of two halves, perfectly distinct from each other in action, as each half receives nervous influence from a distinct source. The number of muscles to

Are the muscles generally arranged to exhibit great force or rapidity of motion? Describe fig. 167. How may the muscles be classified? What muscles are called mixed? How is the number of muscles reduced to 200?

be here considered is thus reduced to a little over two hundred.

452. The *Muscles* may be grouped either anatomically, viz.: according to the regions and layers in which they appear, which is very convenient for dissection, or physiologically, viz.: according to their uses, which is important to the general student.

The anatomical grouping being entirely arbitrary, is differently done by different authors. The following presents one of the best synoptical groupings, and the names will, to a degree, instruct as to the position and use of the muscles.

The muscles are first arranged in five groups: those of, 1st, the head; 2d, the neck; 3d, the trunk; 4th, the upper extremities; 5th, the lower extremities.

MUSCLES OF THE HEAD.

- | | | |
|--|---|--|
| 1. <i>Cranial group.</i>
Occipito-frontalis, | 5. <i>Superior labial group.</i>
(One half) Orbicularis oris,
Levator labii superioris
alaque nasi,
Levator labii superioris
proprius,
Levator anguli oris,
Zygomaticus major,
Zygomaticus minor.
Depressor labii superioris
alaque nasi. | Buccinator,
Pterygoideus externus,
Pterygoideus internus. |
| 2. <i>Orbital group.</i>
Orbicularis palpebrarum,
Corrugator supercillii,
Tensor tarsi. | 6. <i>Inferior labial group.</i>
(One half) Orbicularis oris,
Depressor labii inferioris,
Depressor anguli oris,
Levator labii inferioris. | 8. <i>Auricular group.</i>
<i>a, external.</i>
Attollens aurem,
Attrahens aurem,
Retrahens aurem. |
| 3. <i>Ocular group.</i>
Levator palpebræ,
Rectus superior,
Rectus inferior,
Rectus internus,
Rectus externus,
Obliquus superior,
Obliquus inferior. | 7. <i>Maxillary group.</i>
Masseter,
Temporalis, | <i>b, internal.</i>
Tensor membrana tympani,
Laxator membrana tympani, (<i>musculus externus mullei</i>).
Laxator minor, (<i>thought by some to be a ligament.</i>)
Stapedius. |
| 4. <i>Nasal group.</i>
Pyramidalis nasi,
Compressor nasi, | | |

MUSCLES OF THE NECK.

- | | | |
|--|---|--|
| 1. <i>Superficial group.</i>
Platysma myoides,
Sterno-cleido-mastoideus. | Mylo-hyoideus,
Genio-hyoideus,
Genio-hyo-glossus. | Constrictor superior,
Stylo-pharyngeus,
Palato-pharyngeus. |
| 2. <i>Depressors of the os hyoides and larynx.</i>
Sterno-hyoideus,
Sterno-thyroideus,
Thyro-hyoideus,
Omo-hyoideus, | 4. <i>Muscles of the tongue.</i>
Genio-hyo-glossus,
Hyo-glossus,
Lingualis,
Stylo-glossus,
Palato-glossus. | 6. <i>Muscles of the soft palate.</i>
Levator palati,
Tensor palati,
Azygos uvulæ,
Palato-glossus,
Palato-pharyngeus. |
| 3. <i>Elevators of the os hyoides and larynx.</i>
Digastricus,
Stylo-hyoideus, | 5. <i>Muscles of the Pharynx.</i>
Constrictor inferior,
Constrictor medius, | 7. <i>Prævertebral group.</i>
Rectus anticus major,
Rectus anticus minor, |

Scalenus anticus,
Scalenus posticus.
Longus colli.

8. *Muscles of the Larynx.*
Crico-thyroideus,
Crico-arytænoides, posticus,

Crico-arytænoides, lateralis,
Thyro-arytænoides,
Arytænoides.

MUSCLES OF THE TRUNK.

The muscles of the trunk may be subdivided into four natural groups; viz.,

- | | |
|---------------------------|-----------------------------|
| 1. Muscles of the back, | 3. Muscles of the abdomen, |
| 2. Muscles of the thorax, | 4. Muscles of the perinœum. |

a. Muscles of the back.—The region of the back, in consequence of its extent, is common to the neck, the upper extremities, and the abdomen. The muscles of which it is composed are numerous, and may be arranged into six layers.

First Layer.

Trapezius,
Latissimus dorsi.

Second Layer.

Levator anguli scapulæ,
Rhomboides minor,
Rhomboides major.

Third Layer.

Serratus posticus superior,
Serratus posticus inferior,
Spilnius capitis,
Spilnius colli.

Fourth Layer. (Dorsal Group.)

Sacro-lumbalis,
Longissimus dorsi,
Spinalis dorsi.

(Cervical Group.)

Cervicalls ascendens,
Transversalis colli,
Trachelo-mastoides,
Complexus.

Fifth Layer.

(Dorsal Group.)
Semi-spinalis dorsi,

Semi spinalis colli.

(Cervical Group.)

Rectus anticus major,
Rectus anticus minor,
Rectus lateralis,
Obliquus inferior,
Obliquus superior.

Sixth Layer.

Multifidus spinæ,
12 Levatores costarum,
7 Supra-spinales,
5 Inter-spinales,
6 Inter-transversales.

b. Muscles of the Thorax.—The principal muscles situated upon the thorax belong in their actions to the upper extremity, with which they will be described. They are the pectoralis major and minor, subclavius and serratus magnus. The true thoracic muscles are few in number, and appertain exclusively to the actions of the ribs; they are, the—

11 Intercostales externi,

11 Intercostales interni,

Triangularis sterni.

c. Muscles of the Abdomen.

Obliquus externus (descendens),
Obliquus internus (ascendens),

Cremaster,
Transversalis,
Rectus,
Pyramidalis,

Quadratus lumborum,
Psoas parvus,
Diaphragm.

d. Muscles of the Perineum.

Accelerator,
Transversus,

Compressor,
Sphincter,

Levator,
Coccygeus.

MUSCLES OF THE UPPER EXTREMITY.

The muscles of the upper extremity may be arranged into groups corresponding with the different regions of the limb thus:—

Anterior thoracic region.

Pectoralis major,
Pectoralis minor,
Subclavius.

Anterior scapular region.

Subscapularis.

Teres major.

Acromial region.

Deltoid.

Posterior scapular region

Supra-spinatus,
Infra-spinatus,
Teres minor,

Anterior humeral region.

Coraco-brachialis,

Lateral thoracic region.

Serratus magnus.

Biceps,
Brachialis anticus.

Posterior humeral region.
Triceps.

Anterior brachial region.
Superficial layer.

Pronator radii teres,
Flexor carpi radialis,
Palmaris longus,
Flexor sublimis digitorum,
Flexor carpi ulnaris.

Deep layer.

Flexor profundus digito-
rum,
Flexor longus pollicis,
Pronator quadratus.

Posterior brachial region.
Superficial layer.

Supinator longus,
Extensor carpi radialis lon-
gior,
Extensor carpi radialis bre-
vior,
Extensor communis digito-
rum,
Extensor minimi digiti,
Extensor carpi ulnaris,
Anconcus.

Deep layer.

Supinator brevis,
Extensor ossis metacarpi
pollicis,
Extensor primi internodii
pollicis.

Extensor secundi internodii
pollicis,
Extensor indicis.

HAND. Radial region.
Abductor pollicis,
Flexor ossis metacarpi (op-
ponens).
Flexor brevis pollicis.
Adductor pollicis.

HAND. Ulnar region.
Palmaris brevis,
Abductor minimi digiti,
Flexor brevis minimi digiti,
Adductor minimi digiti.

Palmar region.
Lumbricales,
Interossei palmares,
Interossei dorsales.

MUSCLES OF THE LOWER EXTREMITY.

The muscles of the lower extremity may be arranged into groups corresponding with the different regions of the hip, thigh, leg and foot, as in the following table:—

HIP. Gluteal Region.
Gluteus maximus,
Gluteus medius,
Gluteus minimus,
Pyriformis,
Gemellus superior,
Obturator internus,
Gemellus inferior,
Obturator externus,
Quadratus femoris.

THIGH.

Anterior femoral Region.
Tensor vaginæ femoris,
Sartorius,
Rectus,
Vastus internus,
Vastus externus,
Crureus.

Internal femoral Region.
Iliacus internus,
Psoas magnus,
Pectineus,
Adductor longus,
Adductor brevis,
Adductor magnus,
Gracilis.

Posterior femoral Region.
Biceps,
Semitendinosus,
Semimembranosus.

LEG.

Anterior tibial Region.
Tibialis anticus,
Extensor longus digitorum,
Peroneus tertius,
Extensor longus pollicis.

Fibular Region.
Peroneus longus,
Peroneus brevis.

Posterior tibial Region.
Superficial Group.

Gastrocnemius,
Plantaris,
Soleus.

Deep (posterior) layer.
Popliteus,
Flexor longus pollicis,
Flexor longus digitorum,

Tibialis posticus.

FOOT. Dorsal Region.
Extensor brevis digitorum
Interossei dorsales.

Plantar Region.
1st Layer.
Abductor pollicis,
Abductor minimi digiti,
Flexor brevis digitorum.

2d Layer.
Musculus accessorius,
Lumbricales.

3d Layer.
Flexor brevis pollicis,
Adductor pollicis,
Flexor brevis minimi digiti,
Transversus pedis.

4th Layer.
Interossei dorsales,
Interossei plantares.

453. The muscles may be physiologically arranged as flexors and extensors, adductors and abductors, levators and depressors, sphincters and radiators or expanders.

But this only exhibits their general use—their mode, so to speak, of accomplishing the purpose for which they are brought

into action. A more specific and practical classification is desirable.

454. The *best physiological* arrangement groups together those muscles which act together, and exhibits the purposes for which they act:—1st. Those which act upon the skin, viz., the cutaneous. 2d. Those which belong to the organs of sense. 3d. Those which move and stay the head and spinal column. 4th. Those engaged in speech, breathing, and expression. 5th. Those which move the upper extremities. 6th. Those adapted to locomotion. 7th. Those for eating and swallowing.

455. *Cutaneous Muscles*.—These in man are few. The occipito-frontalis, corrugatores supercilii, several of the facial, and the platysma myoides, are the most conspicuous. The first moves the scalp; the second corrugates the eyebrows; the third in part compose and move the cheeks; the fourth are found upon the sides of the neck, and assist in expression.

The cutaneous muscles might be considered as belonging to an organ of sense, but, as they are not concerned in the production of sensations, they should be distinctly grouped.

456. The most important *use* of the cutaneous muscles is in expression. To accomplish their purpose, they must be exercised under the active influence of those emotions which it is desirable the muscles should express. The first, second, and fourth classes muscles mentioned, are usually overlooked by orators; but, though they are not of the greatest importance, they are worthy of attention and assiduous cultivation.

457. *Muscles of organs of sense*.—These include those of the ear and eye particularly, and also the muscles of the

How many grand anatomical groups of muscles have been made? Describe where the sub-groups are situated? What is the best physiological arrangement? What are the cutaneous muscles, and what their use?

mouth and cheeks to a certain extent. They will be described with those parts.

458. *The muscles which stay and move the head and spinal column may be subgrouped:—a.* Those of the neck. These extend from the cervical vertebræ, the shoulder bones, sternum, and upper ribs, to the head. They are mostly small, but numerous. The largest and most conspicuous are the sterno-cleido mastoid muscles, commonly called “neck-cords.” The head being nearly balanced upon the sockets of the summit cervical vertebra, which encircles the pivot of the second vertebra, and all the other vertebræ being connected by very elastic discs and movable joints, the single or combined action of the practised neck muscles can gracefully produce any desirable motion of the head.

For the perfect action of the neck muscles, the chest must be uncompressed, and the spinal column erect; for if its discs be compressed, the head and face are inclined forward and downward. To remedy this inconvenience, the neck is bent back, which spreads the discs of the cervix unnaturally, and also causes the muscles to be brought into an unnatural condition, and consequently the motions of the head and neck must be stiff and awkward.

459. *b. Muscles of the back.*—Most of these are long and slender, extending between the vertebræ and back part of the ribs. Some large ones, however, extend between the vertebræ and scapulæ and humeri. By the action of these through the arms and shoulders, the head and back can be moved.

For the perfect action of the muscles of the back, they must be left free from pressure, frequently exercised, and as judiciously relaxed. They are ordinarily compressed and their action restricted by clothing; instead of various kinds of exercise and various positions being taken, by which all the muscles of the back will be

Which of the cervical muscles move the head? Is the head moved with difficulty or ease? What is necessary for the perfect action of the neck muscles? What muscles are peculiarly adapted to move the dorsal region of the spinal column?

subjected to use and permitted to repose, only limited exercises and a few positions are taken, by which great inequalities of strength and ability are produced, which assist in producing deformities, and of course prevent any gracefulness of motion from being exhibited when those muscles are called into action.

460. *c. Muscles of the loins.*—These are by one extremity attached to the sides of the bodies of the lumbar and lower dorsal vertebræ, and by long tendons stretch down to be attached to the thigh bones. Their use is to stay the back upon the thighs, and to bend forward the lumbar regions, and, of course, all parts above them. Exercise and repose are their needs.

461. *d. Muscles of the chest.*—Those which are concerned in moving the spinal column are chiefly the straight muscles which pass from the sternum and costal cartilages to the pelvis, in front, the oblique muscles forming part of the sides of the abdomen. See Plate 2. All those which connect between the ribs and spinal column, or shoulders, or head, are means through which the head and back are acted upon.

A perfect state of these muscles is usually prevented from existing by constriction of the chest and pressure of the clothing. Blood is thus prevented from circulating freely through them, while their inaction and improper action enfeeble them with double rapidity. Various and often-changed positions, loose clothing, active exercise, and proper repose, are the requisites for health of these muscles.

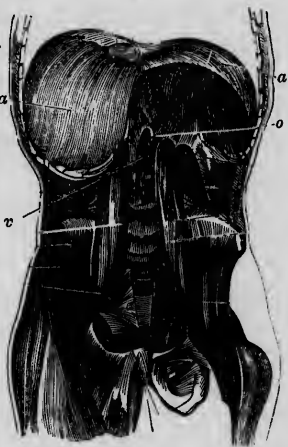
462. The *muscles of speech and expression* include those of *a* the chest; which embrace not only those adapted to produce motion of the spinal column, but also the diaphragm and intercostal muscles in particular, the transverse muscles of the abdomen, and all which in any way operate to enlarge or diminish the chest.

What is the effect of frequently changing the position of the spinal muscles? Where are the muscles of the loins situated? What important muscles of the chest are concerned in moving the spinal column?

463. The *diaphragm* is one of the most important muscles in the body, and a very peculiar one. It is composed of two halves, not precisely similar, on account of the liver being in the right side of the body. The centre is composed of tendinous fibres, from which muscular fasciculi radiate and curve downward (see *a*, fig. 169), to become attached to the cartilages of the ribs.

Those which connect with the sternum and cartilages near it are very short, while their length increases as we follow down the cartilaginous border of the chest to the last rib. The fasciculi which descend behind are gathered into small bundles, which are called pillars. A part of the fasciculi from each pillar pass across to its neighbor. Thus, very adroitly, openings are allowed for the position of the vessels *v*, and œsophagus *o*, fig. 169. In this fig. a portion of the

Fig. 169.

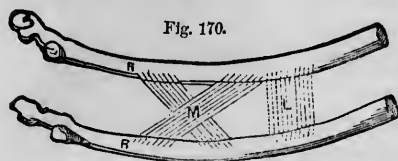


front part of the diaphragm is removed, that the under or inner surface of the back part may be seen. In the sides of the relaxed diaphragm the fasciculi are nearly perpendicular, except in front; those are represented longer than the reality in fig. 169. But the contraction of the fasciculi not only shortens them, but changes their direction towards the horizontal. This muscle is only active in one direction; when it relaxes, other muscles cause its highly arched condition to be again produced.

What is the diaphragm? Where is it situated? How is it constructed? To what attached? What are the pillars of the diaphragm? In what previous figures is the diaphragm represented? What parts are beneath it? What above?

Against its under surface, the liver, and spleen, are placed. Its action is therefore resisted by the walls of the abdomen, which, directly or indirectly, make pressure against the stomach, liver, &c. If the windpipe be closed, the diaphragm cannot contract its sides without depressing the chest or causing a vacuum in it. *Free action* of the diaphragm requires the windpipe to be open, the abdominal muscles to be relaxed, and that nothing prevent the walls of the abdomen from distending. Compressing the waist and suspending the clothing about it prevents the healthful action of the diaphragm, while freedom from restraint and vigorous exercise gives it strength and extensive movement.

464. The *intercostal muscles* exist in two layers, which cross each other, and are obliquely connected with the ribs, as seen at *m*, in fig. 170. If the muscular fasciculi had passed



perpendicularly from one rib to another, as at *L*, they could by shortening one-third their length have moved the ribs but to the

same extent; but now, if the muscles shorten one-third, the ribs almost touch each other.

465. *Another view of the thoracic muscles* would arrange them into those of inspiration and expiration. Those of *inspiration* embrace the diaphragm, the intercostal muscles, the muscles which connect between the ribs and shoulders or head, or the vertebræ above the ribs, including also the muscles by which the shoulders can be elevated, and all those by which the spinal column is straightened and the discs expanded. The diaphragm can increase the perpendicular ca-

What is necessary for the free action of the diaphragm? Describe the intercostal muscles. Describe fig 37. p 115. What muscles are inspiratory? What expiratory? What relations do the oblique and transverse of the abdomen hold to each other?

capacity of the chest; the others, by elevating the ribs, increase its lateral and antero-posterior diameters. The *expiratory* muscles embrace the recti, pyramidal, external and internal oblique, and transverse abdominalis; the intercostales, which, now the lower parts of the chest are the fixed points, depress the ribs upon the same principles as they elevated it; and all the muscles which extend between the ribs and any point below them. The recti and oblique muscles directly depress the chest, and, with the transverse, also press the organs of the abdomen against the diaphragm, and return it to its relaxed arched position. The other expiratory muscles depress the chest.

466. *b.* The *laryngeal muscles* extend between different parts of the larynx, between it and the upper border of the chest and clavicle, and between it, the hyoid bone, the tongue, and the lower jaw. Exercise, repose, and freedom from constraint, perfect the action of these muscles.

467. The *muscles of the throat and mouth* include those of the palate, the tongue, and those which move the jaw. In speech their use is, to articulate the vocalized or expired breath. Exercise and repose perfect them.

468. The *facial* muscles are usually called the muscles of expression, but those of the eye should also be included; and in very forcible expression, not only do the voice, face, and eye similarly exhibit feeling, but all the muscles of the body may be made to exhibit the intensity of the mental action.

469. The *muscles of the handling apparatus* are sub-grouped as those which move, 1st, the shoulders upon the trunk; 2d, the arm upon the shoulder; 3d, the fore-arm on the humerus; 4th, the radius in a rotary manner; 5th,

What muscles are included under the name laryngeal? What muscles are called facial? How are the muscles of the handling apparatus grouped? How are the muscles of locomotion grouped?

the wrist upon the arm ; 6th, the fingers on the metacarpus ; 7th, the parts of the fingers upon each other.

470. The *muscles of locomotion* may be sub-grouped as those which move, 1st, the thigh upon the hips ; 2d, the lower leg upon the thigh ; 3d, the ankle upon the leg ; 4th, the toes and their parts.

471. The muscles of the extremities require exercise under such influences as are natural, and due repose.

The muscles of locomotion are intended for locomotion, to be sure, but for locomotion for certain purposes, viz., either to obtain knowledge, or to supply the wants of the body ; in either of which cases it would be natural for the mind to be deeply interested, and then the locomotion will be performed under proper influences, and will be both successful and healthful. The art of making exercise healthful is, to make it interesting and zestful. The formal procession is of doubtful benefit. The mind must play upon the muscles with all its energy, if it is desirable to have them perfect in action and exhibit graceful motions.

View of the Living Muscular System.

472. A *view of the living muscular system* exhibits it forming a great part of the bulk of the body. It is separated from and loosely connected with the skin, except where the cutaneous muscles exist, by areolar tissue, in which fat cells are interspersed or thickly packed, making smooth the inequalities which the muscles would otherwise present. On the extremities, the muscles surround the bones, and those of the neck the cervical vertebræ. On the trunk, the muscles close the sides of the abdominal cavity, and also the spaces between the ribs, while the diaphragm separates the abdominal from the thoracic cavity. At the front of the abdomen, the broad pearl-colored aponeuroses of the oblique muscles are noticeable, while the dorsal muscles form below a blended mass of tendon arising

Under what influences should the muscles be exercised ? What exists between the muscles and skin ? What parts of what cavities are chiefly formed of muscles ? What are annular ligaments, and what figures in Plate 2 refer to any ?

from the sacrum and the back part of the iliac crest. On the extremities, strong fascia inclose the body of the muscles, and send processes inward to separate and inclose them. The long tendons of the muscles are closely bound to the wrist and ankles by what are called the annular ligaments. See Pl. 2. Wherever throughout the body the parts are liable to be injured by friction, as where the tendons curve round a pulley, pass under or over any part, producing considerable pressure, bursæ are liberally provided. They are particularly numerous about the ankle and wrist.

When they are distended by their accumulated contents, they seem almost as hard as bone, and are often mistaken for a swelling or displacement of a bone. Continued pressure is sometimes sufficient to cause the disappearance of these "swellings," also in common language called "weeping sinews." If this be not effective, the assistance of the surgeon should be required.

473. When *we view the muscular system in action*, sometimes a single muscle is noticed to contract, or even a part of one; but usually they are observed to contract in groups. It will also be noticed that there are two kinds of action at the same time: an intentional one, for gaining the object in view; and another, of which a person without particular attention is unconscious, adapted to the purpose of balancing the system, and sometimes exhibited by almost every muscle in the body except the cutaneous, sensory, vocalizing, and facial. This shows, of course, that all except those muscles are grouped under a single influence, which acts upon them simultaneously, and renders their action harmonious towards a desired end.

474. The *active, living muscle* exhibits and produces several phenomena worthy of notice. When contracting, its

What is the use of the fascia of the extremities? What is the use of annular ligaments? Where are bursæ found? Do the muscles act together or singly? How is the system balanced?

substance undergoes corresponding decomposition; when relaxed, its nutrition is equally active. Heat is also exhibited. At the same time, an increased flow of blood to, through, and from the muscle is observed. This is caused by the pressure of the contracting parts of the muscle upon each other and surrounding parts of the body, which urges the blood from the muscular capillaries into the veins, and through them away from the muscle, while, for the instant, the flow of blood into the capillaries from the arteries is by the same cause prevented; but at the instant relaxation takes place, the gush of blood into the muscle occurs, and the nourishment is poured into the millions of minute ducts through which every portion is supplied.

Inf. a.—Relaxation should quickly follow contraction, or exhaustion of the muscle will be produced; and it must continue for such a period as allows perfect nutrition to take place.

Illus. a.—The meat of a deer “chased to death” is unfit to be eaten, and putrefies quickly.

Illus. b.—Butchers sometimes “dog” cattle a short time before killing them, to make the beef more tender.

Illus. c.—A horse driven quickly with a light load, is exhausted sooner than one driven slowly with a heavy load. A stage-horse frequently improves in “bad going.”

Illus. d.—The lady who quickly plies her needle, though upon the finest cambric, is soon weary, and her muscles ache. The work given to women, and which requires “nimble fingers,” will wear them out quicker than the heavier muscular labors exhaust men.

Inf. b.—Occasional longer intervals of repose, will allow the muscles to become more perfect and vigorous.

Illus. a.—A farmer finds his hands will do more labor, if they have a “nooning.”

Illus. b.—The rest of one day in seven, is found to be a profit to man and beast. The complete and long rest, allowing the muscles to

What phenomena beside motion are exhibited by the contracting muscles? How long should a muscle be relaxed? What effect in his muscles does an animal chased to death exhibit? Mention other illustrations.

become so much more vigorous, that more labor can be done in six than in seven days.

It is better to work harder during the six, and then rest completely, than to rest one seventh of the time scattered through the week. The nutrition of the undisturbed muscles becomes more perfect, as it would seem. An occasional holiday besides is not amiss for the man who labors with his muscles, more than for the scholar, teacher, and professional man. The change of mental action, and the usual mode of muscular activity is genial to the health of both mind and body.

Inf. c.—Rubbing the muscles during periods of repose, must assist in hastening the process of nutrition.

Illus.—A horse will travel much farther and easier, if not only daily rubbed, but also at such times as the traveller stops to rest himself, and his beast.

It is a matter of surprise that the experience and common sense principles, which leads every person who owns a horse, to have him carefully groomed every day, should not have taught men that the same good thing should be done for the human body, which will in fact be more benefited by rubbing, than any animal. Every laborer with muscles or brain, every gentleman or lady of leisure, who cares to labor easily, enjoy comfort, or appear gracefully, should equally and daily, practise rubbing the body from head to foot.

475. But the same muscular action which circulates the blood through the muscle and produces heat there, accelerates the motions of the blood, and distributes heat throughout the body, requiring and producing increased action of the nervous system, the eliminatory, digestive, and respiratory apparatus.

Inf.—The muscular system is thus seen to be a part only of a whole, the other parts of which are equally dependent upon, influenced by, support and influence it.

The relations of the muscular system, and the respiratory apparatus are very conspicuous. The nervous system may be very active without particularly affecting the breathing, but it immediately

When should periods of repose be taken? Why should one day in seven be devoted to rest? What is the effect of rubbing muscles? What other parts beside muscles are affected by their action?

becomes deeper and quicker when muscular exertion is made. The changeable capacity of the chest is also remarkable in the muscular man. All of which shows that there is an intimate relation between oxygen and the decomposition of muscular tissue.

Inf.—One reason why ladies are so easily fatigued by exercise, is that their chests are constricted, while, on the other hand, movable chests cannot be obtained without exercising the muscles generally.

477. *Muscular action influences the mind*, as, on the other hand, the mind exerts an influence upon the muscles. Inactivity of the muscles produces a feeling of languor and ennui, which nothing but exercise can remove. Too active exercise of the muscles causes sensations of fatigue, and prostration or exhaustion. Exercise should never be carried to the point of weariness. It should be taken moderately at first, and gradually increased as the system can bear it. Proper exercise produces delightful sensations, a clearness of the mental vision, and elasticity of spirits, that the indolent never know. When the supply of nutriment for the muscles is exhausted, they produce the sensation called hunger, the pleasurable satisfaction of which is known only to industry.

Review of Chapter.

478. The muscles of the body are very numerous, and may be brought into action singly or in groups, and either voluntarily or involuntarily. Their voluntary action is dependent upon the mind, and is excited through the nerves. Their healthy action is dependent upon their constitution, age, health, and use. They are constitutionally larger and more vigorous in some than in others, and should be used accordingly. In youth they are not large and strong, but active, and

What relation is there between muscular action and respiration? What is one reason that ladies are easily fatigued? What is the relation between muscular and mental action? Upon what is the healthy action of the muscles dependent?

rapidly supplied with blood, and well adapted to carry about the child, where he may see and examine the works of nature, and gather a store of knowledge. But he is disinclined to arduous and confining labor, which is injurious to him.* At mature years the muscles are firm, strong and enduring, and are then best adapted to arduous labor. In old age the circulation of blood is enfeebled, and quiet, and reflection upon stores of knowledge already gained, is for the health of the muscles.

Inf.—The same kinds of exercise are not therefore equally useful to all classes of persons, nor to the same persons at all periods of life.

479. The muscles should be regularly exercised, under proper mental influences, and proper periods of repose should be allowed, and when it is desirable to strengthen them, their exercise should be very gradually increased. The healthy action of the muscles requires an active intellect, cheerful disposition, good health of all parts of the body; wholesome food, water sufficient to satisfy thirst, pure cool air in large quantities, and loose warm clothing in cold weather, and loose thin clothing in warm weather.

* Nothing is more cruel than to compel children to work as is done in some factories, and indeed on some farms, and in some shops. Neither is the constitution of females adapted to the amount of labor which they often undertake, viz., the care of a family, and support of it also. I am sure the men in the world are able to earn enough to support all the women and children in it, and they ought to be willing to do it. Indeed it would be more profitable in the end, for there is enough for women to do, in taking proper care of families and what is earned; and it is economy for those things to be attended to. While also, if children spend their youth in being well educated, they will be better able as men to earn, or as women to take care of what is earned. Besides, the children have a right to be educated well. The public do educate them necessarily, and require them to fulfil duties. Children have a right to require preparation. They are in fact, and in every proper sense, in part the children of the public, and have a right to require the public to be paternal. Again, when women and children are put to work, false compassion gives them light work and little repose. The farmer takes a nooning quietly in the shade, his wife clears off the table; "it's only light woman's work." But rapid motions exhaust the muscles and make deep aches.

What is the condition of the muscles in youth? Are similar kinds and degrees of exercise equally good for all? What does the healthy action of the muscles require?

DIVISION II.

Nervous System.

ANALYSIS—*The purposes of sensation and motion require that all parts of the body be connected with a common centre or centres, in order that any motion which the safety of the body, or other cause renders necessary, may be produced as instantly as possible by a sensation or its causes. No other means of connection exist except the nerves. With this centre, the mind and its organs of thought ought to be associated, that it may appreciate the conditions requiring its action, and the instant a decision is made, cause the execution of its will. As the action of some parts only are to be grouped for gaining a particular purpose, there should be sub-centres for ordinary cases of action, and for those which require a uniform mode of action. With these the mind need not be directly associated. It should be indirectly, so that it may be acted upon in an emergency requiring its aid. The mind must therefore be directly associated with the sensory, emotory, intellectory, and motory nervous apparatus, and indirectly with the involuntary. They must also be associated with each other. Thus the nervous system is a whole, each part of which is directly or indirectly dependent on the rest, and they are all so interwoven, that the anatomist finds it difficult or impossible to exhibit each distinctly, while the physiologist has quite as much difficulty in assigning to each its particular and distinctive office.*

If we notice the muscles contracting, there seems at first to be no cause beyond them to produce their action; it seems to be voluntary on their part; but we soon notice that muscles distant from each other, act in harmony; and it is soon suggested to our minds that there must be some connection between them. The office of the blood-vessels is apparent, and there is no other means by which their conjoint action can be caused except the white cords called nerves. If an experiment be tried by cutting these, the muscles no longer contract as before, and at once they are proved to be the channels through which the contraction is caused; how, no person can yet tell; for, if the nerve be examined with ever so much care, no change or appearance can be detected which gives the least clue to their mode of action. From all the muscles, thousands of these minute white cords can be traced to the spinal cord, but they are constantly uniting with each other, and with those leading from the bones, skin, and other parts which are not nerves of motion but of sensation, as are also many leading from the muscles, and they all appear so similar that it is impossible to separate them after they have united, and their fibres are so minute that as yet it has been impossible to trace them, for often they unite with the spinal cord, so that it is yet uncertain whether any or all of them do really connect with the brain. The different kinds of nervous apparatus are so interwoven, that in this part of our course it is better to describe the whole nervous system together, and conjecture the use of its parts as we best may. That the nervous system, though at first view apparently a whole, is composed of a congeries of apparatus adapted to different purposes, and each of

which, to a certain degree, does act independently of the rest, is shown, 1st. By the simple state in which it is found in some of the lower animals, additions being made to it as additional functions must be performed by the nervous system. (See Fig. 172.) 2d. By the action of the muscles in groups, the muscles being associated apparently with particular centres. 3d. The mind can be as it were disconnected from parts of the nervous apparatus, while its communication with the rest is perfect.

When I have taken ether by way of experiment, incapability of feeling has been first produced, but the will has had perfect control over the motor apparatus, in a few seconds that also has been lost, and the apparatus which excites the emotions and allows their exhibition has had full play, though the will was perfectly decided against it. The will seemed to be put "out of gear" with certain parts of the brain, and though the thinking processes occurred in the most orderly manner, there was no way of showing it to others.* Often when slightly attacked by paralysis, and after fainting, consciousness has remained perfect, but no controlling power over the motor apparatus. The same effort of the will is made, and the same mental sensation, as usual, is connected with the effort, but there is no result. A person may then speak, and is surprised to hear some other words uttered than those he willed.

4th. The distinct locality of some of the nervous centres, and the distinct character of some of the nerves, is strong proof that there are several nervous systems blended in that which is now called the nervous system.

480. There may be *two grand divisions* of the nervous system:—1st. The cerebro-spinal system, which belongs to the apparatus of relation. 2d. The sympathetic, external gan-

* One occasion, which I distinctly remember, was very peculiar; the senses were completely locked up in a few moments, and there was no consciousness of the presence of any external object, nor with the strongest effort of will could the least motion be exhibited. The mind was only conscious of its own existence, and memory with the swiftness of a thousand lightnings, spread out the entire panorama of my life, and passed it before me many a time; in not more than two minutes, every book was re-perused and every face of my boyhood was painted as with a daguerreotype. Then came disturbance of the mental action, and it seemed as if I was rising through spiral circles, hundreds and thousands of years in circuit. This was before I had ever heard of the circles of those who have been in trances. All seemed a reality; and if, when again restored to consciousness, I had not been sure it was all owing to the disturbance of the nervous system, I should have believed that what I experienced was a reality. Though a digression, it may be here said, that in case of such disturbance of the nervous system, the sensations frequently caused, suggest the idea of circles, spirals, &c.

Are the different parts of the nervous system isolated from each other? What proves that the nervous system is a congeries of parts? What is mentioned as the result of taking ether?

glionic, or organic nervous system, which is supposed to belong to the apparatus of organic life; each will be treated upon under its appropriate head.

They are intimately united with each other, and by different authors have been thought to spring from each other. There is no doubt, I think, but that the sympathetic exists lower down in the scale of animal life than the cerebro-spinal; and perhaps, when its functions are unfolded, a minute description of it will be deemed one of the important duties of the physiologist; but at present, little can be said of it which would interest or profit the general student.

481. The cerebro-spinal nervous system may be discussed under three heads—the nerves, the spinal cord, the brains.

CHAPTER I.

The Nerves.

Meaning—Nerves exhibit extremities, a course, roots, ganglia, and a course of action, which are to be considered—Nerves may be classed anatomically or physiologically—Nerves grouped, as, 1st, cerebral; 2d, spinal—Nerves described in their anatomical order—Nerves grouped according to their uses—Special, sensory, motory, and mixed—Utility of grouping the nerves.

482. *Nerve* is the name properly given to those cords which connect with the nervous centres, and all divisions of these should be called branches; but in common use the term nerve is applied to the trunk or branches indiscriminately, and specific names are given, according to the situation of a branch or the part which it connects with the centres.

Thus we have the cerebral, the spinal, and the sympathetic, the sensory, the motory, the respiratory, the white, the gray, the centripetal, the centrifugal, the reflex, the direct, the auditory, optic, cutaneous, the pneumogastric, the cardiac, the splanchnic, the crural, the sciatic nerves, &c. By some they are all thought to

What two grand divisions of the nervous system may be made? Which belongs to the apparatus of relation? Which exists in the lowest part of the scale of animal life? To what is the term nerve properly applied? How is it commonly applied?

Fig. 171.



be parts of one whole, or of a single system, while others think that they might be included under the heads of several systems which are only indirectly connected with each other. There is no doubt but that they are all internuncial in their office, and it is not only not improbable, but probable, that some are used for one special purpose, and some for another, and that they therefore properly belong to those parts between which they extend.

General Characters of Nerves. 1st. Extremities. 2d. Their course. 3d. Plexuses. 4th. Roots and ganglia. 5th. Mode of action and being acted upon.

Two suppositions exist in regard to the external ends of nerves—one that they are looped as represented in Fig. 172, representing a very highly magnified portion of the thumb; another, that from these loops minute fibres branch out and terminate in points. As, however, the sensation caused through a nerve is referred to a definite point, and the muscular tissue acted upon in a definite and cir-

Fig. 171 represents a front view of the dura mater covering the spinal cord and the lower front part of the brain. 1, the part attached to the crista galli. 2, covers the anterior fossa of the cranium. 5, eye. 6, over the sphenoid bone. 7, over the cella turcica. 8, covers the basilar gutter. 9, place of foramen magnum. 10, over the foramen lacerum. 12, below the cavernous sinus. 13, carotid artery. 14, temporal fossa. 15, sides of cranium. 20, place of jugular vein. 24, coccyx. 25, front face of spinal dura mater.—3, the small sheaths of the olfactory nerves, or 1st pair. 4, sheath of optic nerves, or 2d pair. 11, the motores oculorum, or 3d pair—pathetic, trochleares, or 4th pair, and abducentes, or 6th pair. 16, 17, 18, three branches of the trifacial, trigemini, or 5th pair. 19, the facial (portio dura) or 7th pair, and the auditory (portio mollis), sometimes reckoned as part of the 7th and sometimes as the 8th pair. 21, glosso-pharyngeal, sometimes counted as part of an 8th, and sometimes as the 9th pair; pneumogastric (vagus or par vagum), sometimes counted as part of an 8th, and sometimes as the 10th pair; and the spinal accessory, sometimes called part of an 8th, and sometimes the 11th pair. 22, hypoglossal, sometimes reckoned as the 9th, and sometimes as the 12th pair. 23, sheaths of the 31 pairs of spinal nerves.

How are the nerves specifically named? What general characteristics of nerves are to be examined? What suppositions exist in regard to terminations of nerves?

cumscribed manner, it will be proper to speak of that part of the nerve where the action naturally begins or ends, as the extremity of the nerve. Two suppositions also exist in respect to the inner extremities of the

Fig. 172.



nerves; one, that the nerves are looped; another, that they connect with the ganglionic cells. They are so small and delicate, that their course or connections in the centres have not yet been traced in many cases. Wherever their action ceases, or wherever they are first acted on naturally, may be called their extremity.

The *course* of the nerve between its extremities is as short and direct as the nature of the case permits,—each fibre being isolated throughout its entire extent. The general appearance of the nerves is therefore that of radiation from the cerebro spinal axis towards the periphery of the body. (See fig. 6.) The length of different nerves vary from imperceptibly short to several feet.

Plexuses are formed whenever it is desirable to have filaments of different nerves take new and similar directions, as represented

Fig. 173.



by fig. 173. Though the nerves lose their identity, the filaments do not.

Roots are names given to the different parts or nerves of any nerve which is formed near the cerebro spinal axis, and each of which is of course smaller than the nerve formed, in the same manner as the nerve is

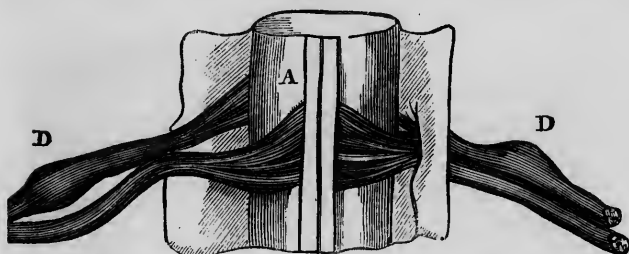
called a trunk in respect to the smaller branches into which it divides. The roots are always toward the centre—the branches away from it.

External Ganglia are collections of grayish cellular and intercellular substance found about nerves, and usually distinguishing the roots of sensory nerves, as seen at D, fig. 174, which represents the two roots of a spinal nerve with the ganglia upon the sensory root.

What may be called the extremity of a nerve? Describe fig. 172. What is the course of nerves between parts? What are plexuses? What are the roots of nerves? What are external ganglia? Why are they so called?

The *mode* in which the *nerves act* or are *acted upon* at either extremity, or throughout their course, it is yet desirable to learn. Some suppose that there is an exceedingly delicate layer of vesicular

Fig. 174.



matter covering the outer extremities of the nerves, and through which they are acted on; but a prick or almost any cause will affect them in any part of their course and cause a sensation. The property by which they cause sensations must, therefore, reside in the nerve itself; which is also proved by the fact, that different causes produce similar sensations through the same nerves, and the same cause different sensations through different nerves—e. g., Pricking a cutaneous nerve causes pain, while the same thing, done to the optic nerve, causes a sensation of light; while electricity and pressure cause a sensation of light through the optic, but pain through the cutaneous nerves.

It is curious to observe that ordinary temperatures do not cause sensations, except acting on the extremities of nerves. e. g., The nerves extending from the feet are acted upon by many different temperatures between the feet and the nervous centres, but no sensations are caused except by the temperatures of the feet. A temperature of 96 at the sciatic nerve produces no discomfort; but let it act at the extremity of the same nerves, in the feet, and very unpleasant sensations will be experienced.

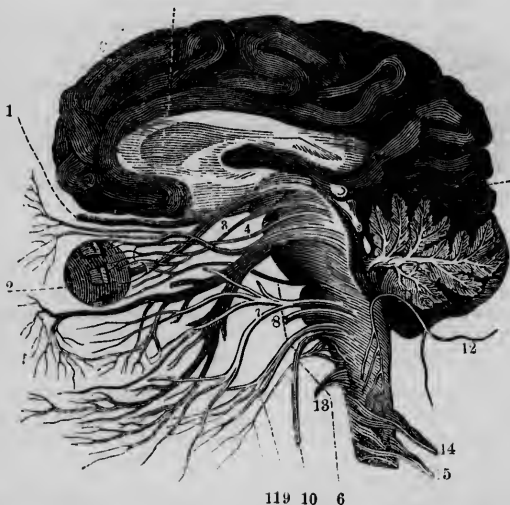
The nerves of motion produce no effects upon any muscles through which they extend—only upon those in which they terminate, and then only to a very limited distance from their extremities, as the contraction of the muscle can be restricted to a very small portion. The nerves conduct, therefore, an influence entirely different from electricity, which they cannot isolate. Heat and various causes can excite the nervous influence, and will stimulate the muscular contractility; but electricity is no more nervous influence, than nervous influence is muscular contractility.

In what mode do nerves act? In what portion of the nerves does the property by which they cause sensation reside? On what muscles do the motory nerves produce effects? Does electricity cause muscles to contract?

483. *Nerves may be classed* either anatomically or physiologically. Anatomically they are counted in pairs, from above downward, as follows; see also Fig. 171 :—

CRANIAL	{	1st.	Olfactory.
		2d.	Optic.
		3d.	Motores oculorum.
		4th.	Pathetici (trochleares).
		5th.	Trifacial (trigemini).
		6th.	Abducentes.
		7th.	Facial (portio dura).
		8th.	Auditory (portio mollis).
		9th.	Glosso-pharyngeal.
		10th.	Pneumogastric (vagus, par vagum).
		11th.	Spinal accessory.
		12th.	Hypoglossal (lingual).
SPINAL	{	Cervical, 8 pairs.	
		Dorsal, 12 pairs.	
		Lumbar, 5 pairs.	
		Sacral, 6 pairs.	

175.



119 10 6

The cranial are classed in 9 or 12 pairs, according to the judgment of authors. I prefer the number 12, and shall speak of the cranial nerves accordingly. They are represented by the preceding partially ideal figure in their natural order:

How may nerves be classed? How many cranial nerves? How many spinal? In how many parts are the cranial nerves classed in this work? Describe the 1st, 2d, etc

Description of Nerves.

1st Pair. What is usually called the olfactory nerve is, in fact, a portion of the brain, and in some animals, the largest part of it. It lies above the ethmoid bone, and from it the proper olfactory nerves extend through the small holes of the ethmoid, and terminate in the upper two-thirds of the nasal lining.

2d Pair. The optic nerve arises by two roots from the lower and inner part of the brain, and extends to the eyes, one half to each; the optic extremities form what

is called the retina. Where the halves cross to the eye of the opposite side, what is called a commissure is formed, and it is said that filaments from one half the brain pass round by the commissure to the other half, and also that filaments connect between the eyes in a similar manner, as shown by the figure 176. Therefore, the commissure is formed of six kinds of filaments, two passing direct from the brain to each eye, two crossing from the brain to each eye, one connecting the eyes, and one connecting the halves of the brain.

3d Pair. The motores oculorum arise from the lower part of the brain, and terminates by five branches in the superior, interior, and inferior recti, the inferior oblique, and the levator palpebræ muscles of the eye.

4th Pair. The pathetici arise from the lower parts of the brain, and extend by one branch to the tentorium, by another branch it is associated with the ophthalmic, but the chief part terminates in the superior oblique muscle of the eye.

5th Pair. The trifacial nerve arises from the lower part of the brain by two roots; on the larger a ganglion exists, near which the nerve exhibits three branches, (see fig. 178) called the

ophthalmic, the superior and inferior maxillary nerves. They terminate in the skin covering the face, except the parotid region, and in the lining of its passages, in its muscles, and in the teeth, by which means all these parts cause sensations, and the nervous filaments connecting them with the brain are thought to form the sensitive root of the 5th. The filaments of the motor root are supposed to terminate exclusively in the muscles of mastication. One branch, called the lingual, has been thought by some to be a nerve of taste.

6th Pair. The abducentes arises by two roots, and connects by a few filaments with the upper cervical ganglion, by a few others with the ophthalmic branch of the fifth, but the greater portion of them terminate in the external rectus muscle.

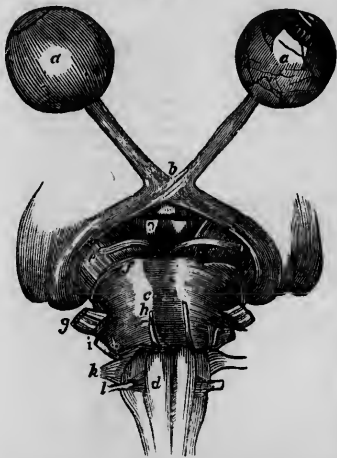
7th Pair. The facial is a motor nerve arising from the lower part of the brain, or upper part of the spinal cord, and terminating in all the muscles of the face, except those of mastication. It has therefore been called the nerve of expression.

8th Pair. The auditory is the nerve of hearing, arises near the 7th and terminates in the labyrinth of the ear.

9th Pair. The glosso-pharyngeal nerve arises from the upper part of the spinal cord, and terminates in the lining of the back part of the mouth, of the pharynx, and of the Eustachian tube, etc. It is therefore a sensory nerve.

10th Pair. The pneumogastric arises near the 9th, and terminates in, 1st, the mucous membrane and muscles of the pharynx and œsophagus; 2d, the mucous membrane and muscles of the larynx and trachea; 3d, in the heart and large arteries; 4th, in the lungs; 5th, in the stomach, so that from its terminations and numerous associa-

Fig. 176.



tions it is probable that a part of its filaments are motor, part sensory, and part organic in their character.

11th Pair. The spinal accessory arises between the roots of the upper cervical nerves, and extends up till it is found by the side of the 10th, and by one branch

Fig. 177.*



terminates in the sternocleidomastoid and trapezius muscles, while the rest of its filaments are so intimately associated with the 10th, that some have supposed the motor filaments of the 10th were derived from the 11th.

12th Pair. The hypoglossal arises from the upper part of the spinal cord, and terminates in the muscles which act upon the hyoid bone, and those in particular between it and the tongue. The spinal nerves are divided into the posterior and anterior branches immediately after they appear outside the spinal column. The posterior branches are short, and terminate in the muscles and skin of the back part of the head, neck, dorsal, lumbar, and sacral regions. The upper four cervical anterior branches form the cervical plexus, from which nerves lead to some of the muscles of the shoulder and

the neck, to the skin of the cervical and parotid regions. From this plexus the phrenic or diaphragmatic nerve, which is chiefly formed from the fourth cervical, with some filaments from the 3d and 5th, extends to and terminates in the diaphragm. The anterior branches of the lower four cervical and 1st dorsal form the brachial plexus, the nerves from which lead to the muscles of the upper extremity. The anterior branches of the dorsal nerves lead along between the ribs and terminate in the muscles and skin of the thoracic and abdominal walls. The anterior branches of the lumbar nerves incline downward, and form the lumbar plexus, from which nerves continue to the muscles and skin of the lower part of the abdomen, of the pelvis, and of the upper and back part of the thigh, while a number of branches from the pelvis form the large crural nerve, which terminates in the muscles and skin of the front part of the thigh. The anterior branches of the sacral nerves form the sacral plexus, from which some nerves lead to the muscles of the lower part of the pelvis, while the greater part of the filaments unite to form the great sciatic nerve, which extends down the thigh just back of and within the femur, and terminates in the numerous parts of the leg and foot.

* Fig. 177 represents the termination of some of the branches of the facial nerve and cervical plexus. 1. Facial nerve. 2. Posterior auricular branch. 3. Temporal branches. 4. Frontal nerve. 6. Infra orbital nerve. 8. Mental nerve. 9. Cervical branches. 10. Superficialis colli nerve. 12. Auricularis magnus nerve. 13. Occipitalis minor. 14. Superficial and deep descending branches of the cervical plexus. 15. Spinal accessory extending by one branch to the trapezius muscle. 16. Occipitalis major nerve.

484. *Physiologically*, the *nerves* may be both *classed* and *grouped*. They may be classed as the special sensory, special motory, and mixed.

485. The *special sensory* are also called nerves of special sensation, and embrace the olfactory, the optic, and the auditory.

486. The *special motory* nerves are adapted to produce motion only, and embrace the 3d, 4th, 6th, 7th, 8th, 9th, 10th, and 11th.

487. The *mixed* nerves are adapted to produce both sensation and motion, and embrace the 5th pair, and all the spinal nerves.

Upon close examination, it is found that the mixed nerves are composed of two distinct nerves; one a motory, and the other a sensory, inclosed in one sheath. For, when a spinal nerve is traced within the spinal canal, it is found to be composed of two roots, one of which is, in fact, a motory, and the other a sensory nerve, with its ganglion, as shown by fig. 174. So also the fifth pair is found to be composed of two nerves, one of each kind, as shown

by fig. 178. The nervous filaments are not, therefore, ever of a mixed character, but each has its specific office, and there are, in fact, but two kinds of nerves.

Fig. 178.



Fig. 178. — 1. Small root of fifth nerve. 2. Large root with its ganglion. 3. Ophthalmic branch. 4. Upper maxillary branch. 5. Lower maxillary branch. *a*, sub-maxillary gland. *b*, sub-lingual gland.

488. The *sensory* portion of the mixed nerves is called nerves

of common sensation, because they are common to so many parts of the body, extending between the bones, the muscles, the skin, and the viscera generally, and the centres.

There are, therefore, many different kinds of nerves, as it respects their connections, and the sensations caused, composing the nerves of common sensation. It is not probable, therefore, that they are similar to each other in structure and other conditions, but they are so blended that the differences, if any exist, cannot as yet be distinguished. It is, however, important, that the student keep in mind, that though they are embraced under one name, there are many different kinds of the nerves of common sensation, which is not a perfectly proper name.

489. *The nerves of sensation may be grouped* : 1st, as those of special ; 2d, as those of common sensation, which may be more fully discussed when the organs of sense are described.

490. *The motor nerves may be grouped* according to their uses, discovered by experiment or conjectured by their connections.

The sacral, and part of the lumbar nerves, extend between the lower extremities and lower part of the spinal cord ; they are very properly grouped as the nerves of locomotion. Part of the lumbar, dorsal, and cervical nerves connect the middle and upper parts of the spinal cord with those muscles which stay and move the trunk and head ; those nerves, very properly, may form a group. Some of the cervical and dorsal nerves connect the spinal cord with the muscles of the upper extremities, and they may be associated in a group ; and as all the muscles mentioned act together sometimes, and as the spinal cord is a continuity of parts, if not one whole, all the groups of nerves mentioned may, with propriety, form one grand group, called the spinal group. The middle of the upper part of the sides of the spinal cord is called the respiratory tract, and between this and the muscles of respiration, speech, and expression, certain nerves connect, which are very properly grouped and called by Bell the respiratory. They are cranial, viz.,

How are the nerves classed physiologically ? What are special sensory ? Motor ? Mixed ? Of what are the mixed nerves composed ? Describe fig. 178. What are nerves of common sensation ? How may nerves of sensation be grouped ?

RESPIRATORY NERVES OF BELL.

- | | |
|---|-------------------------|
| { | 4th. PATHETICI, |
| | 7th. FACIAL, |
| | 9th. GLOSSO-PHARYNGEAL, |
| | 10th. PNEUMOGASTRIC, |
| | 11th. SPINAL ACCESSORY. |

The motor part of the 5th connects the nervous centre with the muscles of mastication. The hypoglossal connects it with muscles which act upon the tongue, and, as I believe, harmonizes its action in the process of mastication, and those two nerves may therefore be grouped. The remaining three nerves connect some of the muscles of the eye with the nervous centre, and therefore may be grouped.

491. This *grouping of the nerves* according to their use, should impress the mind favorably in respect to the practicability of exercising the muscles in groups, as they would naturally be used, and shows that nature has designed that certain parts should be used together, e. g., that the tone of the voice, the expression of the face, and the movement of the eye, should harmonize. This view also shows, that if we wish to use skilfully the muscles of different groups, and rapidly combine their action, the task will be more difficult, and require longer practice, than when the muscles to be used belong to the same group.

492. *Sub-grouping*, and a common origin of many nerves, which connect minor parts with the nervous centres, might be exhibited if space permitted. The practical lesson just given would then be repeated.

493. As the nerves are channels of communication, it would be natural to suppose, that frequent use would improve their condition—also, that pressure, or inflammation, or any disease would prevent their action, and that disuse would enfeeble it.

Illus. When sitting uncomfortably the sciatic nerve is compressed, the foot becomes numb.

What nerves are respiratory according to Bell? What muscles are influenced by the motor 5th? What nerve may be grouped with it? Of what use is this grouping of the nerves? How might the nerves be sub-grouped?

494. Our ideas of the mode in which the nerves fulfil their duty, are so indefinite, that any particular course to be pursued for their benefit, cannot be pointed out.

CHAPTER II.

Spinal Cord.

ANALYSIS—*Spinal cord defined—General characters of the cord—Its protections—Structure—Its uses—Its necessities—How it is preserved in health.*

495. *Spinal cord*, is the name given to what appears externally to be a large nerve, formed by the uniting together of all those which enter the spinal canal. But upon closer examination, it is found to be composed of vesicular matter as well as fibres, and from not gradually increasing in size from below upwards, it is supposed to be something more than a bundle of nerves.

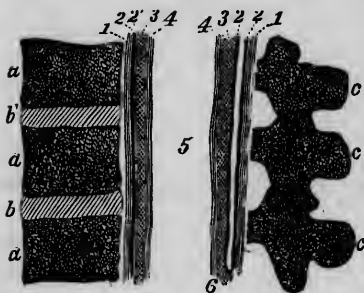
It is thought, and without doubt correctly, to be constituted of both nervous centres and nerves, which are partially isolated from, and partially dependent upon, the brain and mind.

Its *color* and consistence, and general properties, as well as situation, have obtained for it the common name of spinal marrow. In *size* it is about five-eighths of an inch in diameter, exhibiting three enlargements where many nerves are connected with it; viz., at its summit, where it is denominated the medulla oblongata, at the lower part of the cervical and dorsal regions. Three constrictions are also seen in the middle cervical, and dorsal, and at the lowest part. It extends from the brain to the second lumbar vertebra, where it terminates in several large nerves which collectively have received the name of cauda equina, and occupy the remainder of the spinal canal. The position of the lower point of the cord is slightly changed in stooping. The *surface* of the cord is very smooth. It exhibits two grooves in its central front and back part, which indicate a division of the cord into the right and left halves, while two superficial furrows upon the sides mark the anterior, middle, and posterior columns.

What will probably improve the state of the nerves? Give an analysis of Chapter II. What is the spinal cord? Why is it called spinal marrow? Where is the position of the lower point of the cord? Describe the surface of the cord.

Protections of the Cord.—Fig. 179 represents the spinal canal open, and that, 5, the spinal cord, does not fill the spinal canal,

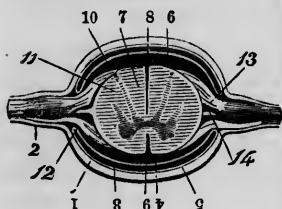
Fig. 179.



but is enveloped by several strata of parts. 1st. It is immediately surrounded by a fibrous sheath, 4, called the pia-mater; the outer surface of this is continuous with a thick layer of areolar tissue, 3; the areolæ of which are large and distended with serous fluid. At the surface of this the fibres again become condensed into a thin fibrous membrane covered with a basement membrane and cells, which compound membrane, 2, is denominated arachnoid membrane; it also lines the dura-mater, 1, which is a thick fibrous membrane lining the canal, but adhering rather loosely by areolar tissue to the bones. The two free surfaces of the arachnoid move upon each other without appreciable friction; while the fluid, by pressure, keeps the cord in place, and at the same time allows it motion. The same general ideas are exhibited by Fig.

Fig. 181.

Fig. 180.



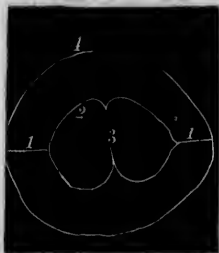
180, which represents a horizontal section of the cord on a line with the centre of a pair of nerves—1 is the dura-mater lining the canal and covering the nerve at 2; 3, is the arachnoid lining 1, just below and above the nerve it passes entirely around the canal, but at the nerve it becomes continuous with 5,

which adheres to the areolar tissue 4. A space apparently exists between 3 and 5, but they in fact touch, but do not adhere. 6 is the delicate but strong pia-mater. The areolar tissue is seen to be thicker at the back than the front part of cord; 7 is the cord in the centre of which the gray part is seen, one of its horns reaching to the surface at 10, where the posterior root of the nerve connects; 8 is the posterior and 9 the anterior fissure partially dividing the cord;

What is the dura mater of the spinal canal? The pia mater? Where, in the canal, is the cord situated? Describe figs. 179, 180, 181. How do the spinal column and its membranes and fluids protect the cord?

13 is the posterior root on which the ganglion is seen; 14 is a process of the pia-mater which separates the roots for a short space, called the lateral ligament, and which, extending to the dura-mater above and below the nerves, forms the ligamenta dentata, as seen by Fig. 181, where 1 represents the spinal cord; 2 the pia-mater; 3 the lateral ligaments; and 4 the dentata. The cord is also retained in the centre of the canal by the fibrous covering of the nerves, which continues from the pia-mater to the dura-mater; and, by the process of the pia-mater, which between the nerves upon each side extends to the dura-mater, as represented by 1. 1., Fig. 182, where 3 represents the spinal

Fig. 182.



cord; 2, the pia-mater; and, 4, the dura-mater. These processes collectively form the ligamenta dentata of the spinal canal.

496. A longitudinal and transverse section of the *spinal cord* shows that it is composed of two classes of fibres, and of vesicular matter, which occupies its centre. One class of fibres are called longitudinal, and the other commissural. The longitudinal appear

to be of two kinds—one are evidently the fibres of nerves, which, as they unite with the cord, incline upward in all the lower parts of the cord, and can be traced for a considerable distance before they are lost in the cord. At the upper cervical portions, the nerves unite almost horizontally, while above that point they incline downward. This arrangement seems to indicate a central point. Some of the longitudinal fibres seem to be for the purpose of connecting together various parts of the cord, and might be classed as commissural. The commissural fibres pass across from one part of the cord to another, and seem to weave the whole into an inextricable confusion; but this is only apparent. Without doubt, the most pleasing, and useful, and orderly relation of parts is established by these means, which will appear simple enough when they are clearly studied out.

Of what parts is the spinal column composed? What are the transverse fibres called? Does confusion really exist among the parts of the cord?

Fig. 183.

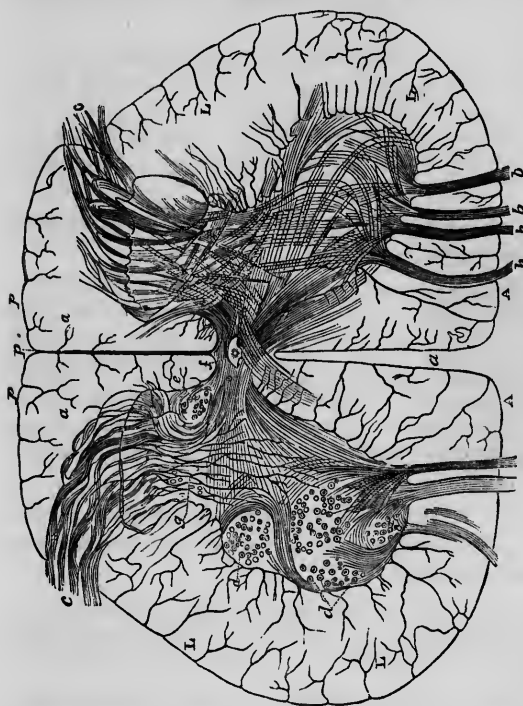


Fig. 183 represents a transverse section of the spinal cord very much magnified; a, anterior; p, posterior fissure dividing the halves; L, L., the longitudinal fibrous portion the vesicular portion; b, anterior; c, posterior roots of a spinal nerve; f, commissure between the two halves, d, vesicular matter.

497. The *uses* of the *spinal cord* seem to be twofold. 1st. It seems to be composed of several nervous centres to a great degree independent of the brain and mind. They are called automatic. The meaning of this is, that through nerves these centres are acted upon, and then immediately and necessarily from them certain influences are involun-

Describe fig. 183. How many offices has the spinal cord? Of what does it seem to be composed? What is the meaning of automatic?

tarily exerted, which by a natural law produce certain results.

Illus. A. When a person swallows food, his voluntary act only passes the food into the throat, when it is swallowed by the automatic or reflex action of the nervous system.

Illus. B. When a person inhales tobacco dust, and sneezes, the whole action is beyond his control. So there are a thousand acts which are automatic or reflex.

498. The 2d. use of the cord is to serve as a conductor to and from the brain.

It is supposed by some that a portion of the spinal nerve filaments terminate in the cord, while another portion extends to the brain. Thus there would be found as many centres as there are distinct termini of the nerves. It is also supposed that a constant influence is exerted from the cord upon the muscles, whereby their tonic state is preserved. However limited the offices of the cord may be, its great importance is abundantly proved by its connections, the quantity of blood with which it is supplied, and the results of disease, accidents, and experiments.

499. The *perfect action of the cord* requires a liberal supply of blood containing the qualities which are nutritious to the nervous tissues.

Muscular exercise and a thorough rubbing of the system, the respiration of pure air, and perfect health of the digestive organs, will act in the most favorable manner on the spinal cord.

500. The *clothing worn* upon the spinal column should be such as will conduce to a healthy circulation of blood about the cord.

In many instances, especially in case of females and children, the upper portions of the column are too thinly clad, while the lower portion of the column is so thickly covered, that great inequalities of temperature are experienced by the cord, which necessarily tend to produce or aggravate disease in it.

What causes the food to be swallowed from the throat? What is the second use of the cord? What does the perfect action of the cord require? How can blood be furnished to the cord?

CHAPTER III.

Encephalon.

ANALYSIS.—*Encephalon* not a single organ, but constructed of several, which are grouped according to their situation, and described—The *medulla oblongata*, including the pyramids, olivary bodies, restiform bodies, and central and round tracts—Their functions—The *pons Varolii*—The *cerebellum*—The *cerebrum*, including the *corpora geniculata* and *quadrigemina*, the *thalami*, the *corpora striata*, the *intellectory ganglia*, and their *commissures*—Membranes of the brain, and its protections—Uses of *cerebrum*—Functions of *encephalon*—Effect of its action upon itself, the mind, the body, and the world at large—Causes of its activity.

501. The *encephalon* includes four parts,—the *medulla oblongata*, *pons varolii* or *mesocephalon*, the *cerebellum*, and the *cerebrum*.

502. The *medulla oblongata*, as its name signifies, is a prolongation of the spinal cord, with which it has many characters in common. It is that part of the enlarged spinal cord which is found in the cranium. It is composed of fibres and gray substance, the latter being more conspicuous than in the cord. On each side are marked an anterior pyramid, an olivary body, a lateral tract, a restiform body, a posterior pyramid, and a round tract.

503. The *anterior pyramids* seem to be mostly composed of the fibres of the anterior column of the cord; and it is especially worthy of notice, that most of the fibres of each pyramid cross over to the opposite side, a part also extending backward, so as to be associated with those of the lateral columns in forming a portion of the *cerebrum* above. From these pyramids arise the motor 3d and 6th nerves.

504. The *olivary bodies* are produced by gray substance embedded in the fibres of the posterior part of the anterior columns of the cord. Their fibres extend up to form part of

- Give an analysis of Chapter III. What parts are called the *encephalon*? What is the *medulla oblongata*? What are the *anterior pyramids*? What nerves arise from them, motor or sensitive? In what muscles do they terminate?

the cerebrum. From a groove between the pyramids and olivary bodies the motor 12th arises.

505. The *lateral tracts*, are narrow columns of fibres, sometimes called a part of the olivary bodies, but they curve back to form part of the cerebellum. From these the motor 7th arises.

506. The *restiform body* is a large column of fibres, continuous below with the posterior column of the cord; and above they curve back to form part of the cerebellum. From the front part of it the sensory, glosso-pharyngeal, and pneumogastric nerves arise.

507. The *posterior pyramids* are small columns, continuous below with the posterior fibres of the posterior column. Above, they extend across and assist to form the opposite side of the cerebrum.

508. The *round tracts* are situated more deeply than the pyramids, which must be spread apart to exhibit clearly the round tracts, which are small, rounded bundles of fibres. From these arise the 4th pair of nerves.

509. The *functions* of all these parts seem to correspond with those of the cord, except that some of them are of a higher order. The medulla oblongata contains both nervous centres and conducting fibres. It seems, both by experiment and connections, to be the nervous centre by which the movements of swallowing and respiration are induced, and, of course, sneezing, coughing, &c.

Inf.—The connections of this centre show why dashing cold water on the face in particular, is likely to excite respiration in many cases when it has not been too long suspended, and also shows that a little will be sufficient.

What are the olivary bodies? The lateral tracts? The restiform bodies? Posterior pyramids? Round tracts? The functions of all these parts?

Great care should be taken not to use so much as to reduce the temperature below what is desirable.

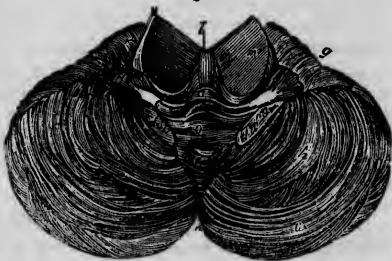
510. The *pons varolii* is mostly composed of transverse fibres which connect the halves of the cerebellum. They do not pass directly from one half to the other, but curve round some distance, and include the fibres of the medulla oblongata, before described, which are interlaced with the transverse. It is therefore composed of, 1st. the transverse fibres; 2d, those fibres which connect the cerebrum with the medulla; 3d, those which connect the cerebellum with the medulla; 4th, a notable quantity of gray substance which fills the interstices of the fibres. From the pons the 5th pair of nerves arise, and a small root of the 6th.

511. The uses of the pons are apparently those of conductors and nervous centres, of which it seems to be one of the higher orders, and is perhaps the first one of the brain with which the mind is associated.

512. The *cerebellum* exhibits externally a gray and white striated appearance. In size, it is about one-twelfth that of the whole encephalon. The form is exhibited by the annexed figure, and figs. 185 and 188. The surface is quite smooth and convex,

except where a shallow furrow indicates a division into halves at the bottom of this furrow; at the upper surface is a slight eminence called the veriform process. It is

Fig. 184.



What is the pons? Of how many kinds of fibres composed? What are its uses? Describe the external appearance of the cerebellum.

composed of fibres and gray matter. The fibres are prolongations of what are called the *crura cerebelli*. These are bundles of fibres obtained from three sources: 1st. The retiform fibres of the spinal cord, called the inferior crus. 2d. The transverse fibres of the pons, called the middle crus. 3d. The fibres which connect the cerebrum with the cerebellum, and called the superior crus. The gray matter is embedded in layers between these fibres, and envelopes the ends of them in such a manner as to present a dentated appearance when the cerebellum is cut across, as seen in fig. 188.

513. Two opinions prevail in respect to the *uses* of the *cerebellum*. Flourens and his followers believe it is a nervous centre, which harmonizes the action of all the muscles in the body. Foville holds that the cerebellum is the organ through which the mind is able to perceive the state of the muscles, viz., that it is an organ of muscular sensation.

Either opinion will account for the singular phenomena exhibited by experiments. If the cerebellum be cut the animal exhibits no signs of pain, but his movements become irregular, and like those of a drunken person. If one half the cerebellum be removed, the animal begins to turn on its horizontal axis, and sometimes as often (says Majendie,) as sixty times per minute, which shows that in some way control over the muscles of one half the body is wanting, while those of the other act for want of opposition. The connection of the cerebellum with the posterior columns of the cord, favors the idea of Foville. It seems unfortunate that the higher we progress in our examinations of the cerebro spinal system, and the more interesting the subject becomes, the less connection can we perceive between the structure and the functions of the parts we examine, and the more involved in mystery is the mode of action, and the more difficult to make clear is the structure of the organs.

514. The *cerebrum* forms by far the largest part of the *encephalon*. It is connected with the medulla by two *crura*

Describe the fibres of the cerebellum. Where is the gray matter found? What is Flourens's opinion of the use of the cerebellum? What Foville's? What is the effect of cutting the cerebellum?

or peduncles, which are mostly composed of fibres continuous with those of the anterior pyramids and olivary bodies,

Fig. 185.



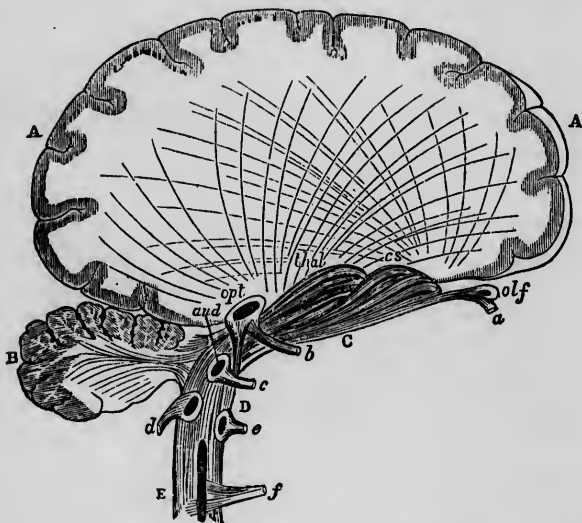
Fig. 185, represents the interior appearance of the meso-cephalon with the origin of the cranial nerves, except the first pair. H, the spinal cord; s, part of the olivary body or ganglion sliced off and turned down to show the origin of k, the 12th nerve; (by Dr. F. G. Smith it is, and with great propriety, called the 11th, as the spinal accessory arises below it, though it apparently leaves the medulla above. See Fig. 175). k, 10th pair, and i, 9th nerve arising from the restiform ganglion; w, restiform tract,

Where is the cerebrum situated?

p. 3.—14.

which together form the inferior crus, and the fibres of the round and posterior pyramids, forming the superior crus. It is connected with the cerebellum by the superior crura of

Fig. 186.



also called inferior crus cerebelli; it terminates in *E*, the cerebellum; *h*, 8th or auditory nerve with two roots about the restiform body; *o* 4, olivary tract, extending up to the thalamus opticus *x*; *g*, 7th nerve, arising by one root from the olivary tract, and by the other from the lateral tract which extends to the cerebellum; *f*, 6th nerve, arising from the pyramidal tract which *p*, *t*, extends through the pons *x* to the thalamus and corpus striatum above *x*; *c*, the superior crus cerebelli; *e*, sensory root of 5th nerve; *em*, its motor root; *d*, 4th nerve; *c*, 8d nerve arising by one root from the locus niger, and by another from the continuation of the pyramidal tract; *b*, optic nerve, arising by four roots; 1st, from the thalamus; 2d, the geniculatum; 3d, the anterior, and 4th, the posterior, tubercula quadrigemina.

Fig. 186, is an ideal diagram of the chief encephalic centres shown by a perpendicular section; *A*, cerebrum; *B*, cerebellum; *olf*, olfactory ganglion; *cs*, corpus striatum; *thal*, thalamus; *opt*, tubercula quadrigemina, or optic ganglion; *aud*, auditory ganglion; *c*, sensori-motor tract; *D*, medulla oblongata; *a*, olfactory, *b*, optic, *c*, auditory, *d*, pneumogastric, *e*, hypoglossal, and *f*, spinal nerves. The lines in the central part of the cerebrum, denote the connections between its ganglionic surface, and the sensori-motor centres.

Which parts of fig. 185 connect with the cerebellum? Which with the cerebrum? Where is the pons situated? What are the peduncles of the cerebrum? What ideas are suggested by viewing the numerous parts and communications of fig. 185?

that organ. The cerebrum and cerebellum may be considered as continuations of the spinal cord, on which the cerebellum, a very simple development, is placed, while the cerebrum is composed of larger and more numerous structures.

515. The crura are essentially conducting fibres, but among them will be found a quantity of gray substance containing black pigment cells, which give to the part the name of locus niger; they must therefore be centres. The third pair of nerves arises from this part.

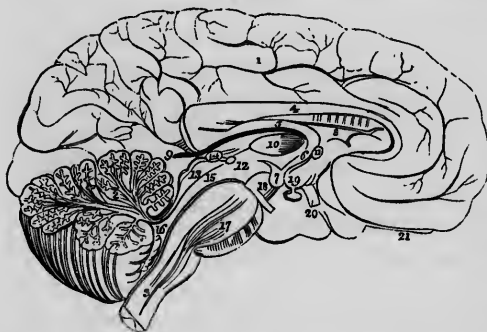
516. If the *fibres of the crura be traced upward* into the cerebrum, they will be found connected with several ganglia, called the corpora geniculata, the corpora quadrigemina, the optic thalami, and the corpora striata; when being greatly increased in number, they radiate outward, and terminate in loops as some think, and in nerve cells according to others, and uncertainly, according to most. Gray substance is embedded among them, and their extremities are so overlaid by it as to give the surface of the cerebrum a very uneven appearance, like that of a peach-stone; the prominences being called convolutions, and their interstices anfractuositities. What has been described is double, and the ganglia of each side are connected by white fibres called commissures, the largest of which is from its firmness called corpus callosum. Fibres also extend between different parts of the same side of the cerebrum, interweaving the various parts, and associating them as it would seem, inextricably.

517. In the formation of these ganglia certain cavities are formed, called ventricles, the sides of which touch each other, but do not adhere. Their utility is not apparent, and they seem to be accidental.

What is the difference between the cerebrum and cerebellum? Where is the locus niger? With what are the fibres of the crura cerebri connected? Describe the surface of the cerebrum. What are the cerebral commissures?

518. An *external view of the cerebrum* exhibits first, a deep fissure at its front, upper, and posterior central line, indicating its division into two halves or hemispheres. Viewing the hemisphere on its side, it appears hemispherical above, but below it is irregular, and by indentations is marked into three lobes, called the anterior, middle, and posterior. The under surface of the cerebrum is very irregular, and the back part somewhat concave, being situated upon the tentorium, and directly above the convex cerebellum. The in-

Fig. 187.*



side of each hemisphere is nearly perpendicular, three-fourths or four-fifths of that surface being free, the rest being occupied by the commissures

of the halves. The whole surface of the cerebrum is convoluted, the size of the convolutions differing in different parts of the cerebrum, in different people, and at different ages.

519. The brain is immediately covered by a very delicate membrane, called the pia-mater. At the upper part and sides of the brain it is constructed of little more than blood-vessels, but towards the base of the brain the fibres are numerous. Next to this membrane, and adhering to it, upon the convolutions, a basement membrane covered with

* Perpendicular surface of the 1. Cerebrum. 2. Section of cerebellum. 3. Cord. 17. Medulla. 16. Crus cerebelli.

What is the external appearance of the brain? Describe membranes upon brain.

cells is found, and called arachnoid membrane. Its cellular surface is free, and moistened with a serous fluid. The arachnoid, existing for the purpose of lubrication, need not pass down into the anfractuositities, as the blood-vessels ought, so it passes across from one convolution to another, while what is called the pia mater follows the surface of the brain. The arachnoid and pia mater together form a serous membrane, which is here analyzed into its components of fibrous and secretory membranes. Near the base of the brain, as said, the fibres of the pia mater become numerous, and also a layer of areolar tissue is formed between the pia mater and arachnoid, constituting what is called the sub-arachnoidean areolar tissue; it connects with the similar structure about the cord, and the areolæ are filled with fluid, so that the brain rests upon a hydrostatic bed, supported by a column of fluid—the most admirable protection against the effect of jars with which the brain could be furnished.

520. Upon the other side, the cranium is lined by a very thick coat of fibres, called the dura mater, and this is lined by basement membrane, with cells upon its inner surface. These two are called the arachnoid of the dura mater. From the cen-

Fig. 188.

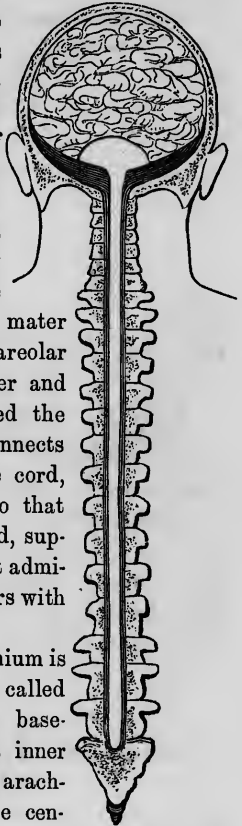
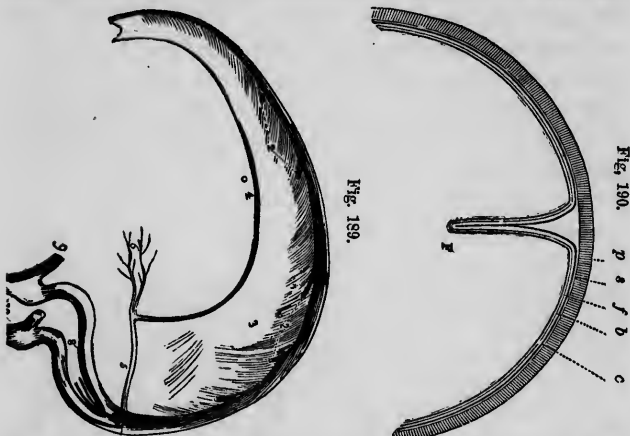


Fig. 189. *a* represents somewhat rudely the areolar tissue beneath the brain and around the cord.

Describe figs. 187. 188. Can the brain move in the skull?

tral line of the front, upper, and back part of the inner surface of the cranium, the dura mater extends down between the hemispheres of the cerebrum as far as to the surface of the corpus callosum, whence it extends back again to the skull, and



lines it as before. This partition is called the falx. Its form is seen by fig. 189. The arrangement of the dura mater is shown by fig. 190, by which it is seen that there are 12 simple membranes between one half of the cerebrum and the other when the falx is in its place; or, as the two fibrous strata of the falx are blended, there will be 11.

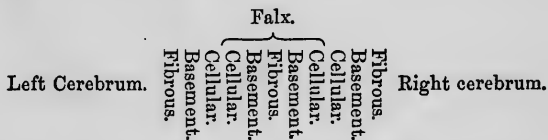
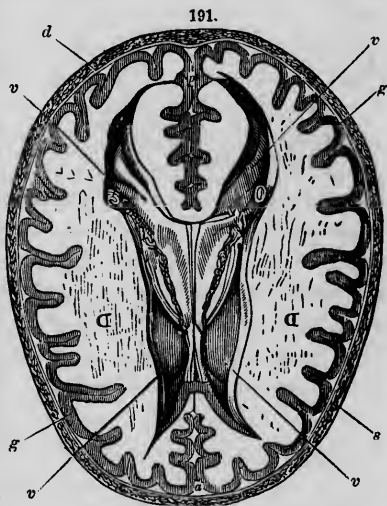


Fig. 189. Side view of the falx stretched between the halves of the cerebrum, and supporting them when the head is turned to either side. 1, anterior part and commencement of veins. 4, 6, called sinuses. 5, 6, 7, 8, 9, veins.

Fig. 190. Rude view of a section of the falx and skull. *p*, Periosteum. *s*, Skull. *f*, Fibrous. *b*, Basement. *c*, Cellular membrane. *F*, Falx, at the upper part of which the triangular sinus is seen.

521. From the inner occipital ridge the dura mater extends forward, forming a kind of shelf upon which the posterior part of the cerebrum rests, and by which the cerebellum is covered. The same number of simple membranes exist here as in the falx. As, therefore, the cellular surfaces, which are free and moistened, extend around all parts of the brain except where obstructed by the commissures, nerves, or blood-vessels of the brain, it can move with great freedom in its bony case, which it completely fills, but to which it does not adhere.

522. If a slice of the brain be removed, a contrast of color between its gray external layer and its chiefly white internal fibrous part is conspicuously exhibited, and the inequalities of the surface are seen to depend on those of the white part. If a deeper slice be removed, the ventricles are presented to view, and the corpora striata, quadrigemina, and geniculata, and the thalami opticornum, with their connecting commissures. These ganglia collectively are called the sensorium, though it is by no means certain that their office is entirely sensory.



Section of the head; s, skull; d, dura mater; a, anterior, p, posterior fissure; g, g, grey substance; D, fibrous substance, v, ventricle.

Where is the falx situated? Describe figs. 189. 190. How many simple membranes between the halves of the cerebrum? Where is the tentorium situated? What is exposed by slicing off the brain?

Indeed, it would be equally correct to call them the motorium. The rest of the cerebrum is called the cerebral hemispheres, or intellectual ganglia.

Some minor parts of the brain have not been described, because nothing could be said about them which would be satisfactory.

523. *Uses of the Cerebrum.*—It is not possible, in the present state of science, to determine with accuracy the particular uses of the various parts of the cerebrum. The prevailing idea at present is, that the thalami are the ganglia through which sensations are chiefly produced on the mind, and that the corpora striata are those ganglia through which the will acts to cause motions. But whether the thalami act upon the mind directly, or through the cerebral ganglia, is a debated question; as it is also whether the mind directly acts upon the striata, or through the medium of the cerebral hemispheres. There seems to be evidence, as has been shown, that there are ganglia peculiar to each kind of sensory nerve; and I believe there are. The best conclusions at which I can arrive in regard to the whole matter are the following. The spinal cord and medulla contain nervous centres, the office of which is, to receive and exert influences which are altogether unfelt and involuntary. The parts between the medulla and the cerebral hemispheres can act upon the mind, causing sensations; and, on the other hand, the mind can act upon them, and cause voluntary and orderly movements. From all the muscles of the body, influences are exerted through the inferior crus upon the cerebellum, which then, through the superior crus, exerts harmonizing influences upon the cerebral centres, from which they are exerted upon the various parts of the body. These centres, in the vicinity

What parts are called the sensorium? Through what part does the will act in causing motion? What is the office of the centres of the medulla and cord? How is it probable that the contraction of the muscles is harmonized?

of the pons, are also so connected and associated, that, after frequent repetition of mental, in connection with physical influences, at last the physical is sufficient to alone cause the accustomed action.

Illus.—When the mind has often associated the action of certain muscles in playing a piece of music, the physical effect of each note excites the action of the muscles which will produce the next. It is thus that habit enables a person to do many things without especial mental attention, and leaves the mind free for other duties.

524. The centres now under consideration also have an office in exciting the emotions, and their close connection, or identity in part, with the sensory ganglia, is worthy of observation. Thus the emotions may easily and involuntarily be excited, and act either upward upon the cerebral ganglia, or downward upon the muscles, and manifest themselves outwardly; or the mind, by recalling experienced sensations involuntarily, excites the emotions previously connected with them. The cerebral ganglia are adapted for the use of the mind in all its higher operations, which are usually called intellectual and volitional. But whether the mind has its seat in the gray peripheral portion of these ganglia, or in the central ganglion, is altogether conjectural, as is also the mode in which the mind uses these ganglia.

525. The *functions of the entire encephalon* are fivefold—sensory, emotory, intellectory, motory, and sanatory.

However great the uncertainty may be in regard to the functions of specific parts of the brain, there can be no doubt in regard to it as a whole.

526. The *accomplishment of these functions* affects—
1st. The encephalon itself. 2d. The mind. 3d. The body.
4th. The world at large.

What is the effect of repeated action of the pons and its neighboring parts? What parts of the nervous system are concerned in producing the emotions? Where in the brain is the seat of the mind? What are the functions of the entire encephalon?

527. The *action of the brain* is constantly and necessarily attended with change of its substance.

Inf.—The action of the brain should never be greater than in accordance with its nutrition.

528. The *activity of brania*l changes and nutrition will depend upon natural constitution, age, manner in which they are produced, and upon the quantity and quality of blood flowing to the brain.

a. The constitutions of different persons differ very much in respect to cerebral activity; and though this may be modified a great deal by education, especially in early life, the constitutional tendency can seldom be entirely eradicated. Those whose nervous systems are sluggish should be placed in circumstances of an exciting character. A city life stimulates such to a natural degree of action, and they appear cool and collected where ordinary men are carried away by too hasty action. An excitable nervous system will dislike quietude, but it should frequently be sought, surrounded by those circumstances which will tend to circulate the blood through other parts of the body more than through the brain.

b. That age affects brania

l activity is too evident to need remark. That kind of activity should be encouraged which is adapted to the age. Muscular inactivity is not best for the child, while it is for old age. The studies and duties of life should be adapted to that development of the brain which nature has intended should be produced. Let it be remembered also, that this development takes place step by step, and therefore every moment of life must be profitably employed in order to prepare us for the next. And every moment of the waking hours may be profitably and actively employed, in exercise of the sensory, emotory, intellectual, or motory functions.

c. The manner in which the brania

l changes are produced is of great consequence. There is a natural order of things—a natural mode of action, both of the mind and of the world around; and there is, no doubt, an adaptation of the brain to these modes of action. Shakspeare is the most illustrious example of the application of this idea. He first acts through the ear by the delightful influences of music; then through the eye by beautiful or wild scenery; he then addresses the emotions, and thus, approaches the

What effect attends the action of the brain? Upon what does the activity of brania

l changes depend? What kind of life excites brania

l changes? What effect does age have upon the rapidity of cerebral changes?

intellect. Now, there is no channel through which the nervous system can be aroused, or the circulation to it increased so quickly, as through the ear; the emotions can thus be very quickly stirred; the fife and drum make boy or man step more martially; angry tones soon stir angry feelings, &c.; and the near relation of the sensory to the emotory ganglia shows the reason for this. It is also noticeable, that if one emotion is excited another can easily be. If a man will laugh, he can easily be made to cry, and vice versa. The emotions act through their commissures upon the intellectory ganglia, and also cause that increased flow of blood which reaches to the parts above. In early life, especially, and in case of all those who have not by habit acquired a facility in the use of the intellectual ganglia, I believe the sensory and emotory ganglia should be used freely, either in attempting to give instruction, or to persuade. When the music and scenery of Shakspeare cannot be had, let another expedient of his be used; paint to the imagination what is not presented to the eye, or call up the scenes of youth, or stir the emotions of patriotism or sympathy, or let something mirthful excite to action those parts of the nervous system which so favorably affect those other parts which it is so desirable to reach. Here is the secret of part of the success of some orators endowed with extraordinary and impressive voices, of illustrated works, and those which are highly imaginative. But there is a natural mode of action of the intellectory parts of the nervous system. Demosthenes, Webster, and all such men, looked at things in a natural order of cause and sequence. Hence the advantage of reading the ancient authors in their own tongue, and the works of men who have thought rightly. It habituates the mind not only, but the brain, to a natural mode of action, so far as those persons were right, though it is equally bad where they were wrong. Hence the advantages of mathematical studies. A long course of study is also necessary in order that the intellectory ganglia may be properly active without the assistance of the sensory or emotory. This state is partly produced naturally as age advances.

d. The *quantity of blood* flowing to the brain is partly dependent upon the action of the brain itself, but is increased by proper muscular activity. It is not, therefore, a waste of time for the student to take muscular exercise, more than it is for him to cultivate and gratify the emotions. On the other hand, it is one of the means which he must take for mental improvement both direct and indirect. The necessity of muscular exercise, or its ad-

How does Shakspeare act on the mind? What relations have the emotions to each other? What is the physical advantage of reading those languages and the writings of those men in which ideas are naturally expressed?

vantage in respect to the nervous system, does not seem to exist after mature age and nervous action has arrived. The temperature of the skin also affects the quantity of blood in the brain, as, on the other hand, the circulation in the brain is apt to lower the temperature of the skin. The student should therefore be warmly clad. The digestive process requires blood in large quantity, and therefore, when it should be active, the brain should not be, for, if it is, indigestion is likely to ensue.

The *quality* of the blood is affected by the air, the food, the water taken, and by the action of the respiratory, digestive, and eliminatory apparatus.

The *air* must be pure, and as the respiratory action does not seem to be especially affected by the nervous activity, it is very important that the student breathe cool air; whereas, on the other hand, not clothing themselves sufficiently, they are apt to feel cold, and to endeavor to remedy the evil by elevating the temperatures of their rooms. The chest must also be free and extensively movable.

The *food* taken should correspond in quantity and quality with the degree of nervous activity. In ordinary food but a small proportion of nutriment for the nervous system exists, and a liberal allowance of it will be required. It should be well prepared, and the health of the digestive organs must therefore be carefully preserved.

The *quantity of water* taken by students is usually greater than is needed. When in too large quantity, it distends the vessels, and thus produces oppression, while it also prevents the brain from receiving nutriment as rapidly as is desirable.

The *action of the eliminating apparatus* is very important. Excretory substance should never be allowed to circulate through the brain, it has a peculiarly deadening effect upon it. Carbonic acid soon causes a stupor, and the influence of all the other excretions are more or less unhealthy. Hence bathing and attention to the eliminating organs, are matters of vital consequence to the student.

529. The *action of the encephalon* upon the mind produces sensations either pleasant or unpleasant, while inactivity of the brain causes unpleasant sensations.

Most parts of the brain do not cause pain when they are cut, but yet it is productive of the most exquisite sensations, either

What affects the quality of blood? Why is it important to the brain that the air be pure? What should be the character of food for the use of the brain? What quantity of drink should the student take? What is the effect of bathing?

pleasurable or painful, not only when it is excited to action by other parts of the body, but when itself alone is active. It has been constructed for activity, and its activity is essential to its own health and the well-being of the entire man. The sensations it causes correspond. Some suppose that the sensations experienced when the emotions or intellectual faculties are active, are owing to the mind's action alone; but the emotory sensations are precisely similar to those produced when the emotory action is not caused by the mind; and I believe that all these sensations are produced by the action of the brain upon the mind. It matters not, the practical conclusions are the same; the activity of all those emotions and faculties which tend to a man's own good, or that of society, which in fact is the same thing, produce pleasant sensations, while every emotion, passion, or mental act which is injurious, is productive of unpleasant sensations. Too active or prolonged exercise of the nervous system is injurious, and causes sensations of discomfort, perplexity and exhaustion. Intense application of the mind should not therefore be indulged too long; but should be intermitted, by a new direction of mental action. *Inactivity* of the nervous system is productive of sensations of ennui almost insupportable. One great reason for the uneasiness, dissatisfaction and restlessness that persons manifest is, that their minds have not been educated nor their nervous systems exercised properly. All parts of the brain require action, and a person cannot enjoy life without he produce the proper activity.

530. The *action* of the *encephalon* upon the *body* is exhibited in two ways. First, it exerts a constant influence upon all parts, conducing to their health, or the reverse, as the case may be. It exerts a constant influence upon the muscles, till after a time they exhibit the usual state of the brain. Nothing is more certain than that the action of the brain tends to produce, prevent, or remove indigestion; while the healthy action of the skin is superintended by influences derived from the same source. The health of the parts not only, but the beauty of expression and loveliness of complexion is dependent upon the brain. Second, all the voluntary movements of the body are produced through the brain.

What sensations are produced by activity of the brain? What emotions have a healthful influence upon the brain? What is the effect of allowing the brain to be inactive?

531. The action of the brain upon the world is entirely dependent upon its action on the muscular apparatus of the body, the complexion, etc.

532. The action of the brain is caused by the nerves, the mind, and the blood, and its own constitution.

533. Through the nerves *two kinds of influences are exerted*, one from without the body, and one from within.

The influences of external objects on the brain are not sufficiently appreciated; they are constantly acting and producing effects. They ought therefore to be such as will produce favorable effects upon the changes of the brain, and through it upon the mind. Nature has produced a thousand beautiful objects, and they ought to be allowed to educate the mind. Pleasant tones of voice, music, and beautiful flowers, all tend to develop the emotions and store the intellect. Such riches may be had without money and without price. The nerves extending from all parts of the body also exert influences upon the brain. Indigestion causes unfavorable effects upon the brain. Loading the stomach with too much food, or eating that which is unwholesome, is prejudicial to the brain. The usual action of the muscles as well as their transient, exert influences upon the brain; e. g., let a person place his muscles in the attitude of any particular emotion, and soon it will be excited. Let the muscles of expression imitate any expression of feeling, and they will tend to produce the feeling. Thus frequently by imitating the usual expression of any person, his character can be appreciated, e. g., if a person wishes to feel stingy, let him imitate the face of the miser.

534. The action of the mind upon the brain is the great cause of its activity, and entirely so of its controlled action.

Hence, as the mind is, so will be the action of the brain upon the body and world. The eye has well been called the window of the soul; not only through it does the mind look out, but through it also another can look in. Not only, then, for the health of the brain, should the mind be cultivated and refined, but for the health of the whole body as well, and not less, for the sake of personal appearances.

535. *The action of an intelligent mind with a cultivat-*

How does the brain act upon the world? What are the causes of encephalic action? What influences are exerted through the nerves? What are the proofs that the body influences the mind? What is the cause of the controlled action of the brain?

ed, actively amiable disposition, is essential to the perfect health of the brain, and through it to the perfect health of the body, its beauty of complexion, attractiveness of expression, grace of motion, or melody of voice.

536. By the *action of the mind habitually* the ordinary action of other influences than its own, can be controlled to a certain and very great degree.

The mind can either withdraw itself from certain parts of the brain, or shut off their action; or, by calling into intense action other parts, draw away the blood to them, so that undesirable influences cannot be produced. On the other hand, it can give attention to parts, and cause them to become very active, and produce very powerful effects from slight causes. Thus it can refine its taste and appreciation of objects which are good, or it can allow the slightest causes to produce irritability, moroseness, and all the characteristics of ill temper.

537. The circulation of the blood produces changes in the brain, and of course excites its activity.

The rapidity and character of the changes depend much upon the quality of the blood. When some persons are burdened by ennui, or disturbed by unpleasant thoughts, they endeavor to change their sensations by the use of poisons, viz., those things which produce an unnatural and unhealthy influence upon the brain. They use alcohol, opium, or tobacco. Either through the nerves or blood, these things produce effects upon the brain, modifying its changes and activities, and of course the sensations it produces.

Inf. One way to promote temperance, will be to make happy homes, and to furnish young people with agreeable society; for either of which purposes it is necessary that all persons should be well educated.

Then will their brains be active in a healthful manner, and the sensations caused will be such, that they will not be inclined to seek the delirium which is more evanescent than the passing cloud, and always leaves a bitterness; for the brain excited unnaturally, will always in a short time produce most unpleasant feelings of depression.

What kind of mental action is essential to the health of the brain? What is the effect of habitual action of the mind? What effect has the circulating blood on the brain? How may temperance and good society be promoted?

CHAP. III.

Sympathetic Nervous System.

ANALYSIS.—Reasons for the names of the Sympathetic System—Composition of Ganglia and Nerves—Their functions; their number and arrangement—View of living nervous system.

538. The name *Sympathetic* was given to a portion of the great nervous system, at a period when it was believed to be the means of establishing what were called sympathies between different parts of the body. As branches of this portion of the nervous system extend to the parts of the head and trunk, some of which receive no other nerves, it was called the *organic* nervous system, and as it is composed in part of many ganglia, it is called the ganglionic system.

539. It is *composed* of ganglia and nerves. The ganglia are small in size, and composed of nerves which extend through them, and those which commence in them, of nerve cells connected with the nerves, and of others embedded between them. They are directly enveloped with a delicate fibrous capsule and surrounded with areolar tissue.

540. The *function* of the nerves of this system is that of conductors, without doubt, while the function of the ganglia is to receive and produce influences, and also to transmit them. It is supposed that the influences they receive and produce have reference to the involuntary motions of the viscera and to nutrition and secretion. It is supposed that usually the parts with which the sympathetic nerves are connected, exert influences no further than the ganglia; but when the cause of action is intense the influence is extended

Give the analysis of Chapter III. What are the names of the sympathetic nervous system, and why is it so called? Of what is it constituted? What are the supposed functions of this nerve?

to the spinal cord and brain, through which the mind is acted on, and pain caused.

Fig. 92.



Six pairs of ganglia are situated in the head, four of them being particularly associated with the 5th pair—see figure 178. These may be said to be one class, and by some are grouped with those of the spinal nerves. Three pairs exist in the cervical, 12 in the dorsal, 4 in the lumbar, and 4 or 5 in the sacral regions, nearly corresponding to the intervertebral foramina. They are connected by nerves which, with the ganglia, form a chain or gangliated cord upon each side of the bodies of the spinal column. The ganglia are also connected with the neighboring spinal nerves—as shown by figure 192, where *s* represents the sympathetic, connected by *e* a gray and white nerve, with the spinal nerve, which by *a*, its

anterior, and *p*, its posterior root is connected with *c*, the spinal cord. Nerves also communicate between the ganglia of the opposite sides, and those from different ganglia by uniting with each other, form larger nerves, which extend to the viscera of the chest and abdomen. For the most part, the nerves of this system follow the course of the arteries, and form plexuses about them. In the course of these nerves or branches of nerves more ganglia are formed.

Review and View of Living Nervous System.

If we notice the living nervous system, many nervous centres or ganglia are seen with internuncial nerves connecting them with

How many pairs of ganglia in the head? How many in the neck? How many in the remainder of the chain?

all parts of the body. The largest ganglia of all fill the upper, middle, and back part of the cranium. Its gray or vesicular matter forms its entire surface, between different parts of which, and between it and the ganglia found in the central lower part of the cranium, commissural fibres connect. In the central ganglia the gray matter and the white fibres are very much blended, while below, throughout the length of the spinal cord, the gray matter occupies a central position. All these centres and nervous collections are carefully encased and protected. Again, we observe a great number of small ganglia, upon the front aspect of the cranium and spinal column, connected with the large ganglia within, with each other, and with the organs of the face, neck, chest, abdomen and pelvis—and perhaps following the arteries into every part of the extremities. If the action of all these parts be observed, it will be noticed, that with the speed of lightning, influences are constantly being exerted between the centres and the various parts with which their nerves connect, modifying the action of all parts of the body, and causing very active changes of the nervous centres to be necessary. The blood will be seen flowing to, through and from them, without intermission, and undergoing rapid changes as it gives nutriment and receives excreted substance from the parts it visits. But as the encephalon is regarded, it will be seen that the mind must also be taken into consideration, for it both modifies the brain and is modified by it. Every external influence, which acts on any part of the body, and every condition of the body, can be traced till its termination is found at the mind, while on the other hand, every state of the mind diffuses an influence spreading wider, and wider, till it operates on every part of the body. Whoever sees this clearly, will appreciate that a person with a cultivated and exercised ear, eye, muscles, and every other part through which the world acts, and a body healthy naturally, and preserved so by exercise and the use of proper food, drink, air, and clothing, and a mind with cultivated intellectual and emotional powers, is a person possessed of inalienable wealth—and able not only to enjoy, but daily enjoying all the happiness that the world can bestow—not dependent on nominal possessions, but on his own capabilities—not dependent on the non-possession of others, but on the fact that it is the heritage of all men who will exercise their bodies and properly educate their minds.

On the other hand it will be appreciated that the scholar cannot study, nor the teacher teach most profitably in badly ventilated,

In noticing the living nervous system, what parts are observed to occupy the head? What the spinal column? What to be situated in front of the cranium and spinal column? What is the effect of action of all these parts?

cold, or highly heated school rooms. Legislators, judges, jurors, or lawyers cannot do their duty well in similar circumstances: The doctor cannot advise best when fatigued by over duty, and above all no legislator, judge, juror, lawyer, doctor, or other person, can do his best when his blood is poisoned with alcohol or anything else. While most important of all no mans brain can operate to the best advantage, without a man is in every sense of the term, a noble minded and good man. If therefore we wish due, responsible services of a man, we should among the first questions ask, is he a good man—does he expose his brain to the action of poisons—is he fatigued, &c.

DIVISION III

Organs of Sense.

ANALYSIS.—Sensation is produced by action of the brain upon the mind. First cause fourfold: the brain, the nerves, the parts in which the nerves commence, the objects which surround the body. These act through six classes of organs of sense. Four classes of objects act through the skin—Their mode of action—Its structure—Nerves of touch. Savory objects act through parts of the mouth—Its structure as an organ of sense and mode of action—Its nerves. Odorous particles act through the nose—Its structure and mode of action—Its nerves. Three kinds of light emitted, transmitted, and reflected, or absorbed by objects, which determines their color. The eye needed that their direction may be determined—Its protections, structure, use, and mode of action—The optic nerves. Waves of air act through the ear—Its structure, use, and mode of action. The contraction of muscles being resisted, sensations are caused by which the mind determines the solidity of bodies.

Sensations in General.

SENSATION is the name of any effect produced by the brain on the mind, and of which it is conscious. So far as we know, the brain is the only part by which the mind is acted upon. The sensations frequently seem to be in other parts of the body, but they are not. After the arm is removed, pains seem to be felt in the hand, and do not seem to be in the brain, where they are produced. The fact is, we are so constituted as to refer the sensations to various parts for the purpose of directing attention to them. The brain, then, is the part which in all cases is the direct cause of the sensation. In other words, the brain is associated with the mind, and any state of the brain produces an effect on the mind which is pleasant or unpleasant, as the necessity of the case requires. It

Give the analysis of Division III. What is a sensation? To what parts do we refer sensations felt? What is the immediate cause of sensations? Do dissimilar causes always produce like results?

matters not what cause produces any particular state of the brain, the sensation it produces is the same; the cause may be the mind, or disease, or the blood, or an influence exerted through the nerves, the resulting sensations will be similar, provided these dissimilar causes produce similar states of the brain. The same is true of the nerves; their effects upon the brain will be similar, provided similar states are produced in them, even by dissimilar causes.

Inf.—The cause of a sensation cannot always at once be determined, nor where the cause is acting.

541. The causes of sensations may correctly enough be counted as fourfold: 1st. The brain; 2d. The nerve; 3d. The part in which the nerve commences; 4th. The external object which acts upon the body.

542. The *action of the brain* itself, independent of any cause except the mind, produces the most intense sensations the mind experiences.

The health and perfection of mind and body is dependent to a great degree upon cerebral activity, which has, therefore, when proper, been made correspondingly pleasurable, as a reward and inducement, while inactivity, or improper activity, is attended with discomfort, both as a punishment and an inducement. The exercise of those parts of the brain associated with the affections and social faculties, and all the benevolent emotions, is particularly delightful; and if honest industry will count up the delights of life which he cannot obtain, he will find them very few. Can riches buy for him the wealth of his gratified affections? In his wife, his children, his parents, his brethren, and his neighbors, has he not a store which is inexhaustible? How much could he add to happiness with money? He might gratify vanity, love of ostentation, and show contempt for his fellow-men; but does not the exercise of his brain, under such influences, produce unhappiness? He might gratify his benevolence, true, and this would add to his happiness; he might more highly cultivate his mind, and this would be for his good; but after all, let him fairly make a computation, and see if he have not within his reach the greatest portion of happiness that mortal can enjoy, and if his unhappiness do not spring from the cultivation of envy, jealousy, pride, &c. I call

If sensations are similar, is it certain that their causes are? How many general causes of sensations are there? What effect does activity of the brain have upon the production of sensations?

no man poor who has the rich sources of gratification which an affectionate family affords.

543. The diseased brain frequently produces sensations similar to those usually caused through the nerves. Over-action of the brain causes it to produce pain, and diseases of other parts of the body cause it to produce intense pain.

Illus.—Derangement of the digestive organs frequently cause headaches. Indeed, they are generally to be attributed to the improper use of food; though not eating food, or not enough of the proper quality, causes headaches.

544. Some diseases of the nerves cause the most excruciating pain, and as the pain usually seems to be at the outer extremities of the nerves, the real seat of the disease is overlooked.

545. The nerves commence in all parts of the body, except, perhaps, the cartilages, and any state of the part affects the nerve, producing what is called an impression upon it, then through the nerve an effect is produced upon the brain, then upon the mind, and a sensation results.

546. If the various parts of the body be healthy, pleasant sensations, if unhealthy, unpleasant sensations are caused.

The unpleasant sensations vary very much, as, hunger, thirst, weariness, fatigue, lassitude, cold, heat, etc. The kinds of pain are almost innumerable, and by them alone a skilful person can sometimes determine what part is diseased, and in what way.

547. *Pain* is evidently for the purpose of calling the attention of the mind and causing relief to be given. While pleasant sensations are for the purpose of inducing a continuance of the state.

This is not, however, always a safe rule, for pleasant sensations are sometimes produced by poisons. Man has not been endowed

What sensations does the diseased brain frequently produce? How do diseased or deranged states of the body produce sensations? What sensations do some diseases of the nerves produce, and to what part are they referred?

with ever-protecting instincts, but with reason, judgment, and a natural desire to acquire knowledge, all of which must be cultivated.

548. All those sensations which have their cause in the body, may be called internal or subjective, while those which have their cause outside the body, may be called external or objective.

CHAPTER I.

Sensation of Touch—Its objects and organs.

549. There are four classes of objects that act through the skin, to produce sensations of touch. 1st. Those which merely come in contact with the skin. 2d. Those which change its temperature. 3d. Those which compress the skin. 4th. Those which disorganize it.

550. How those objects, which merely come in contact with the skin, produce effects on the nerves, is uncertain.

It does not always seem to be by pressure, for this may be so gentle as hardly or not at all to exist. It may be by electrical influence.

551. The use of the effect produced by touch, is merely to inform the mind of the presence of objects, and their position in respect to the body.

Inf. As the presence of these merely in contact with the skin is neither harmful nor beneficial to health, the sensation is neither pleasant nor disagreeable, but neutral.

To some persons, however, certain objects of touch only, are pleasant or disagreeable, especially when a smooth or rough object is moved over the skin.

552. *Objects which change the temperature* of the skin, act directly on the nerves, and indirectly by affecting the blood-vessels.

How many classes of objects act through the skin to cause sensations? How do objects touching the skin act on the nerves? What is the use of sensations of touch?

These objects act not, therefore, by virtue of touching the surface of the skin, but by acting upon it deeply, or causing it thus to be acted on. It matters not, therefore, what temperatures exist ever so near to the skin, if the skin is not affected. But if objects are in contact with the skin they will affect it. They must therefore be warded off by clothing. The most healthful temperatures of the skin are caused by heat produced within the body and preserved in the skin. But to produce heat most rapidly, cool air to breathe is necessary. To keep the skin of a proper temperature, therefore, cool air near to the skin must be permitted, but it must be prevented by proper clothing from acting on the skin.

Inf. As the temperatures of the skin are of the greatest importance to health they ought to be productive of the most intense sensations.

There are no sensations more pleasant than those produced by healthful temperatures, or more annoying than those caused by unhealthful temperatures. This ought to teach to correct the evil. But people will frequently allow the skin to produce sensations of chilliness without correcting the evil, or if they attempt to do it, it is by elevating the temperatures which act on the skin, and thus in the end bring on themselves a second evil. Thus people allow their feet to become and remain wet and cold; ladies in particular, wear too little clothing, or expose themselves in cool evening air, or stormy weather, with no more clothing than usual, and that so tight that heat cannot be abundantly produced, and then complain of cold hands and feet. Children are clad with short-sleeved and low-necked dresses, and thus are caused to almost constantly suffer from sensations of chilliness, which tend to render their dispositions fretful. Oftentimes people unawares sleep with too little clothing beneath or above them, and not then feeling any unpleasant sensation, they find upon waking that they have taken a severe cold.

553. *Continued pressure prevents the circulation of blood.*

Inf. a.—It ought to cause unpleasant sensations.

Inf. b.—Seats of every kind should be comfortable, and positions frequently changed.

Inf. c.—Tight dress ought to produce unpleasant sensations—and

Why should the skin be protected by clothing? Are the sensations produced by the temperatures of the skin easily perceived? Are they pleasant or disagreeable? When and how do people suffer from sensations of chilliness?

of course to tend to cause irritability—which is very far from rendering a lady attractive.

Inf. d.—Tight shoes cause unpleasant sensations in three ways: by direct pressure on the nerves, by preventing the circulation of the blood, and causing too low temperatures for health.

554. All objects which disorganize or divide the skin, are of course injurious, and should produce unpleasant sensations; the use of which is, to call the attention of the mind to the dangers to which the body is exposed.

555. The *Skin* is called the organ of touch.

It is composed of three membranes, a thick external cellular membrane, the external cells of which are dried into the state of horny scales—and serve as a protection to the delicate parts below. This layer is kept soft and flexible, by an oily fluid constantly poured out upon its surface. Part of the deeper cells of this layer contain a pigment, which in part gives color to the complexion. The perfection of this layer depends upon a free circulation of blood in its immediate vicinity, and upon its surface being kept clean, both that excreted substance, and the dry oil may be removed, and that the air and light may perfect its pigment.

Inf.—The skin must be kept of a healthful temperature, frequently and thoroughly rubbed; muscular exercise must be taken, and mental action must also be favorable.

The second layer of the skin, is the exceedingly delicate basement membrane. Beneath, is found the fibrous membrane, containing the vessels and nerves. The whole constituting what is called the true skin or dermis. The surface of this which is next the basement membrane is uneven, and presents prominences called papillæ, and these again, especially on the hand, are arranged in rows.

556. The *nerves of touch* commence in the papillæ of the skin, very near to the basement membrane, in the form of loops, as it is usually supposed, one particular point of which may be looked upon as the extremity of the nerve.

557. For the healthy action of the nerves, there must be

What is the effect of continued pressure upon the body? Illustrate. What is the organ of touch? How is it constituted? How should it be preserved in a good condition? Where do the nerves of touch commence?

a free circulation of blood through the dermis, which is very abundantly supplied with blood-vessels.

Whether this is in order that nutritious substance may be supplied to the nerves, or that they may be preserved of a proper temperature, or both, is uncertain. The importance of the active circulation is positive.

Inf.—Rubbing the skin and muscular exercise, must tend to improve the sense of touch.

558. These nerves soon become associated with those of the muscles, bones, and other parts, and extend with them to join the cerebro-spinal centres. It is probable, however, that all the cutaneous nerves are associated with only two common ganglia, which might be called the cutaneous ganglia.

CHAPTER II.

Sensation of Taste, and its Organs.

559. *Taste* is the name given to the sensation ordinarily caused by objects taken into the mouth.

560. Food and drink are the ordinary objects which cause taste; but almost any substance allowed to dissolve in the mouth will excite the sensations of taste—how, is uncertain.

Usually, the more soluble any substance, the more readily is it tasted. Fluids are, therefore, more active than solids. But as some gases excite taste, and others do not, so is it with fluids. By some, it is supposed that the particles of tasted substance must pass into the mucous membrane, and act directly upon the nerves; while others think that an influence is exerted upon the nerves, but that they are not touched by the substance tasted. According to the former, fluids readily pass into the membrane; according to the latter, they spread over the surface more perfectly than solids.

561. The uses of taste are, to enable a person to distin-

What is necessary to a healthy action of the nerves? With what nerves are those of touch associated? What is taste? What are the objects of taste? What are the uses of the sense of taste?

guish substances, and to change the duty of eating into a pleasure.

The sensations caused by food which is relished, assist not a little in the digestion of the food. Every one can witness to their causing the saliva to flow freely into the mouth. Dr. Beaumont also testifies to their similar influence in causing the juices of the stomach to flow into it.

562. No one of the senses is more susceptible of cultivation than that of taste.

Inf.—It should be cultivated so as to highly relish wholesome food.

There is nothing which tends to increase the pleasures of eating more than a hearty appetite.

Inf.—Exercise of the nervous and muscular systems and exposure to the fresh air should be taken, in order to produce a demand for food, and its accompanying appetite.

563. Food should be selected, 1st, which is wholesome; 2d, which is relished; and then cooked so as to be, 1st, wholesome; 2d, relished.

The comfort and attractiveness of a house is not a little increased by a well-set table. The expense is no greater to have whatever food is prepared, well prepared, and neatly set forth. Many a temper has been soured by sour bread.

464. The *mouth* is termed the organ of the sense of taste. Its cavity receives the substance to be tasted; its muscles and teeth grind it; its salivary glands furnish fluid to dissolve it; and the mucous membrane of the upper surface, and the sides of the back part of the tongue, and the sides of the back part of the mouth, is composed in part of nerves which, when acted upon, excite the sensation of taste.

565. The *mucous* membrane of the sensory parts of the mouth is formed into *papillæ*, which are easily seen by the

Why should the sense of taste be cultivated? How can an appetite be produced? Upon what principles should food be selected and cooked? Describe the mouth as an organ of sense? What are *papillæ* of the tongue?

naked eye; but with a glass, the sides of these are found to be formed into small papillæ. In these, just below the basement membrane, the nerves of taste commence.

In them also, and in the mucous membrane of the mouth generally, nerves of touch commence, and both kinds soon become associated with the motor nerves of the lingual muscles; and it is not, therefore, certain what large nerve is the nerve of taste. By some, the glosso-pharyngeal is thought to be it; while others think the office devolves upon the lingual branch of the fifth: fibres for taste probably exist in both nerves.

The nerves of one side of the mouth and tongue are entirely distinct from those of the other; and, for purposes of taste, there are therefore two tongues, united by the central line. Sometimes the sensations produced through the two sides are not similar.

CHAPTER III.

Sensation of Smell, and its Organs.

566. *Smell* is the name given to the sensations ordinarily caused through the olfactory nerves.

567. The *objects* of this sense are exceedingly minute particles of matter dissolved in the air. Whether they act by passing into the membrane and touching the nerve, or by merely exerting an influence upon the nerves through the cellular and basement membranes, is uncertain.

568. The *utility of this sense* in man does not seem to be as great as in case of some animals. It warns of some dangers. It enables him to distinguish objects; it excites the appetite, and increases the relish of food.

Its effect upon the mind is, however, much more powerful either in respect to attraction or repulsiveness than is usually supposed. The freshness of morning, and the sweet fragrance of the flower-garden, charm more than is acknowledged. Judiciously selected perfumes are as advantageous in forming the toilet as personal un-

Where do the nerves of taste commence? How many kinds of nerves commence in the tongue? Through what organs is the sense of smell produced? What are the objects of this sense? What is its utility?

cleanliness is disagreeable. This is a sense which can be highly cultivated. But in these days of uncleanly personal habits, badly ventilated rooms, cars, &c., of tobacco using, alcohol drinking, and other infringements of public rights, it is doubtful whether it is not best to do all that is possible to render this sense obtuse.

569. The *nose* is called the organ of the sense of smell. The upper parts of the nasal cavities are only properly so called.

Fig. 193.

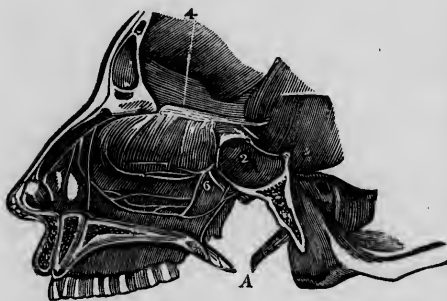
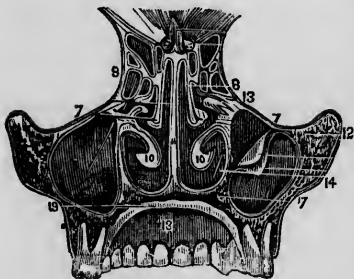


Fig. 194.



The nose is composed of two equal halves, entirely distinct from each other, and which in fact are the organs of smell. Each nasal fossa is partially divided by the turbinated bones into three spaces, called the inferior, middle, and superior meatus. It is lined by

mucous membrane, which is rendered very extensive by means of the turbinated bones. It is constantly covered with its own secretion, and still further moistened by the tear fluid, which, however, is poured into the fossa below the sensory part. A lubricated condition of the membrane is necessary, in order that the odorous particles may act upon the nerves, for when in case of a cold the membrane

becomes inflamed and dry, the power of smelling is lost.

570. The *narrow spaces of the nasal fossa* cause the in-

Has any person a right to render the air which another must breathe, offensive? What part of the body is the organ of the sense of smell? Describe the nose.

haled air to be warmed, to act more extensively on the nerves, and to a certain degree serve to detain dust from passing to the lungs.

Inf. a.—When the air is so cold as to injure the air passages, or produce coughing, it should be inhaled through a muffler, or something which will warm it.

Inf. b.—If a person be situated in a dusty atmosphere, he may guard the air passages by means of a wet sponge tied over the mouth and nose.

If the air be very cold when it enters these delicate passages, it sometimes causes inflammation there. The inhalation of dust and its deposit in the nasal cavity irritates its membrane, and causes an unhealthy state of it.

571. The nerves of smell commence in the upper part of the nasal cavities by extremities which are too small to be distinctly seen, even by the assistance of the microscope. They are exceedingly numerous, and as they associate together form a kind of flexus, from which small nerves extend up through the holes in the cribriform plate at the roof of the nose, and connect with the olfactory ganglia, usually called the olfactory nerves.

CHAPTER IV.

Sensation of Sight, and its Organs.

572. *Sight* is the name given to the class of sensations, usually produced through the eyes. Its use is to enable a person to distinguish objects, but especially their direction from him.

Inf. a.—During waking hours, the use of the eyes is very important, and almost constantly required, and the sensations produced through them should be pleasant.

Why should the nasal passages be narrow? In which part of the nose do the olfactory nerves commence? To what sensations is the name sight given? Why should they be pleasant?

Inf. b.—As the use is almost constant, some way must be contrived by which the eye can be rested during its use.

This can be, as it is, by having several kinds of light, so that while one is acting, the eye can be in repose in respect to another. It may be, and doubtless is the same in respect to the brain—for the mind must be constantly active during waking hours, and the brain ought not therefore to suffer, and doubtless will not if all the powers and activities of the mind are brought into play. So the eye does not suffer if there is a proper alternation in the action of different kinds of light upon it.

573. *Light* is the name given to the objects which act through the eye upon the optic nerves. Light is of three simple kinds—*Red*, *Yellow*, and *Blue*.

These or their compounds produce all the various and numerous sensations of sight, except the sensation of blackness. This is caused by the action of the nerve alone. In this respect it seems to be different from any of the rest, and constantly active, and when no light is acting upon it, it causes a sensation of black, which is hence called a negative sensation and color.

Fig. 195.



574. The *proportions* in which these act on the eye determine the pleasant or unpleasant character of the sensations experienced.

Inf. The art of rendering colors attractive, consists in presenting such a combination of colors before the eye, as shall naturally and necessarily please.

The natural proportions of the colors of white or sunlight are 3 Red, 5 Yellow, and 8 Blue, and whenever colors are so combined that these proportions of light are presented to or move across the eye, they must be productive of health and pleasant sensations. Red and green harmonize, and the green should much predominate, as in that most beautiful object in nature, a moss rose bud, because blue and yellow when they act together, produce the sensation of green, and they would together make 13 parts in 16, which represents the white light. Orange and

Fig. 195.—A diagram to show how colors are complementary. Those at the angles of a triangle or the diameter of the circle are so.

How can the use of the eye be constant, and yet repose be given to its nerves? How many kinds of simple light are there?

blue are likewise beautiful colors in harmony. Orange being produced by red and yellow acting together, blue is the remaining complementary color. It will be seen by Plate 8, that the blending of blue and yellow produce green, while red and yellow produce orange. The more highly compounded the colors are, the more difficult does it become to read the simples of which they are composed. But when they have been obtained, it is very easy to see what color is wanting, and what superabundant. The more the colors are blended, and the greater the variety of shades, the more pleasing as a usual thing the sensations they cause. For the same reason small figures are more pleasing than large, except in the carpet of a large room, when the eye looks over a large surface, and the same result is produced, viz., no one color acts long upon the eye. Flowers are beautiful on account of the delicate blending of their colors. This is especially the case with the budding rose, which from its attractiveness has been chosen as the fit emblem of love, while the bold-faced dahlia can hardly be looked upon as a flower. The beauty of blended colors is still better seen in a tastefully arranged bouquet, than which there is no surer gift to please or win the good feeling of boy or man, girl or woman. The persuasiveness of its colors, and the eloquence of its perfume, will be more commanding than all the gold of California's mines.

575. The objects which cause light to act through the eye, are of three kinds: 1st. Those which produce. 2d. Those which transmit. 3d. Those which reflect light.

The sun is the great fountain of light—when we feebly supply the place of his bright rays, it should be with light as nearly similar as possible. There are three respects in which it should be similar. 1st. The proportions of the different kinds of light should be similar. The gas of our cities is very good on this account. Next to that, lard oil, and spermaceti, stearine, or wax candles, are the best substances with which I am acquainted. Next in order is whale oil. Spirit gas and camphene are both very bad, and in the end unprofitable. 2d. The quantity of light should be considerable. On this account gas is very good, as it produces a brilliant light. A solar lamp for lard, or lard oil, is next in order, both for economy of expense and brilliancy of light. Next in order would be the same lamp used with whale oil. 3d. The direction from whence the light comes should be upward, or a shade should protect the eyes from the direct action of the

Why do red and green harmonize? Why do orange and blue? What proportion should orange and blue bear to each other? How many kinds of objects cause light to act on the eye? What will determine the character of the sensations they produce?

light. If the shade is about the lamp, the room generally is apt to be darkened, and turning the eye toward it, causes too sudden a change in its state. All these things are not only important for the health of the eye, and for the use of the student, but quite as much so for the lady who wishes to be attractive either by her dress or furniture.

Window glass and lamp shades are most frequent illustrations of objects which transmit light, but window blinds and the semi-transparent sides of bonnets are quite as important to notice. Where curtains, shades, or blinds, are used, they should be such as transmit the kinds of light which the objects within are adapted to reflect. e. g. If green curtains line the windows, and there is a red carpet on the floor, it will appear sombre. Such curtains are frequently seen at windows, at the sides of, or above doors. Scarcely a young lady in the world has a complexion so florid that she would appear well in the hall, or when at the door. For if the daylight poured in through the open door, only green would pass through the curtain, and too large a proportion of green would therefore be received by and reflected from her complexion, which would appear sallow and ghastly, as any one may see by holding a piece of green paper near to the skin. The kinds of light which will be transmitted through the bonnet, are to be considered when its trimming is selected, and adapted to the complexion.

Almost all objects reflect light; as in case of those which produce and transmit it, they are called by the name of the sensation which they produce. Some objects do not reflect any light; these are called black. Some reflect all three kinds in their natural proportions, and are called white objects and good reflectors. Some do not reflect one kind, some do not reflect two kinds, some reflect all three kinds, but not in their natural proportions, which ideas are represented on the left hand side of Plate 8. In arranging dress, goods, furniture, paintings, bouquets, flower-gardens, and every thing the effect of which is dependent on color, all these matters of the production, transmission, reflection and combination of the different kinds of light must be regarded.

576. The distinguishing of these objects and their directions, is dependent upon three things. 1st. Each one causes the light to act from it in every direction in straight lines, till it passes into some object of different density. 2d. The eye is so constituted, that it causes all the light which falls

What should be regarded, in producing artificial light? In what modes and in what way is light best produced? What should be regarded, in selecting objects for transmitting light? What objects reflect light?

upon a certain portion of its surface from any minute point or visual object, to be refracted or bent to the same point, as illustrated by Fig. 2, Plate 8. 3d. Man is so constituted as to instinctively believe when a certain point of the eye is acted on, that the object causing the sensation is in a certain direction.

Almost the entire difficulty which has been experienced in understanding optics, arises from a misconception in regard to the objects of vision, and a misapplication of terms. A visual object is the smallest point or collection of matter which can cause a distinct sensation. (The idea is rudely exhibited by figs. 5 and 6, Plate 8. See description.) This is also a mental object, but usually a mental object is compounded of many such—as a leaf, a limb, a tree, a forest. These are all creations of the mind, from the simple visual objects which have always one definition. The visual object can never, of course be inverted, for if the blue and the yellow be erased from fig. 2, Plate 8, and the red alone left, it will be seen that there can be no inversion, only one point being left in the eye. If this point be not inverted, any number of others cannot be. The reason why inversion has been so generally supposed to result is shown by fig. 9, Plate 8. (See description.)

That the objects may be distinguished, it is necessary that the light passing from them should act on different nerves. This end might be gained by such an arrangement as represented by fig. 1, Plate 8, but in such a case only a few objects could act at once. The effect upon the nerves would not be sufficiently intense, and the precise direction of objects could not be determined. With the arrangement as at fig. 2, millions of objects may act at the same time, each producing its own sensations intensely, and at the same time its precise direction may be perfectly appreciated. If it be above, the point acted upon must be below; while if the point of the eye acted on be above, the object must be below the axis or horizontal line of the eye. Thus simply, beautifully, and perfectly, is the mind at the same time pleased and stimulated to action, and able to direct the body towards those things which it wishes.

577. The *eye* is called the organ of the sense of sight. It may be treated upon under the head of its appendages and protections, and the eyeball.

By what means is the direction of an object visually distinguished? What is a visual object? What is the distinction between a mental and visual object? Why is it necessary that light, radiated by different objects, should act on different nerves?

578. The protections or tutamina and appendages of the eye, include the sockets, the eyebrows, eyelids, eyelashes, muscles of the lids, the lachrymal glands and ducts, the meibomian glands, the puncta lachrymales, and nasal lachrymal ducts, the fat, and the muscles.

The *sockets* are conoidal cavities, formed by the orbital surfaces of the maxillary, unguis, ethmoid, frontal, sphenoid, and malar bones.

The *eyebrows* require no particular remark; to preserve their health and beauty, they should be rubbed and brushed.

The *eyelids* are composed of the skin, which forms their external and internal surfaces, of the muscles and meibomian glands between the two, and of the cartilages, which exist near the border. It is remarkable that no fat is ever found in this part.

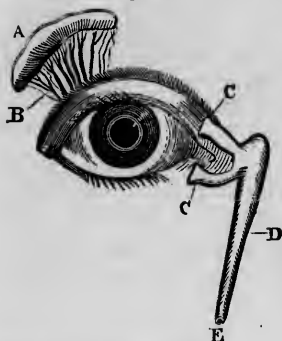
The *eyelashes* are beautifully curved, so that when the lids are shut, they interlock, as shown by the figure following.

Fig. 196. The *muscles* of the lids, are three in number. The orbicularis, Plate 2, the tensor tarsi or Horner's muscle, and the levator palpebræ. The first closes the eye, the second draws inward the edges of the lids, or the tarsal cartilages, the third elevates the upper lid, thus opening the eye. *a*, Fig. 198.



The lachrymal gland is about the size of a sparrow's egg, is situated in the socket near its outer and upper edge; from it several

Fig. 197.



minute tubes or ducts lead down, and open towards the eye, on the under surface of the upper lid. Its use is to form the tears, and pour them down into the eye—this it does slowly most of the time; but at times the large quantity of fluid it will pour out is surprising. It is especially connected with those parts of the brain concerned in the production of the emotions, and exhibits very clearly their involuntary influence. It is also associated with other centres, which can equally influence it—as is seen sometimes when a person has eaten mustard, and its volatile particles have af-

ected the back part of the nose and upper part of the pharynx.

The *meibomian* glands exist in the upper lid, opening by seve-

ral tubes at the edge of the lid. They are very simple, and form a viscid semi-fluid, which is serviceable in preserving the front part of the lids perfect.

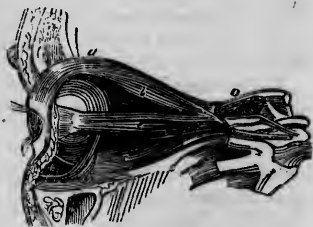
The *puncta lachrymales*, are two minute orifices and tubes, found at the inner part of the lids, and easily seen by turning them out slightly, see fig. 197. They curve round, and open into the nasal duct, which terminates in the inferior meatus of the nose. The upper part of this is called the lachrymal sac. It or the minute puncta sometimes become closed from the effect of colds, and then the tear fluid constantly runs over upon the cheek, subjecting a person to much inconvenience, and the eye at last to inflammation. If when the cold is removed, the tubes are found to be permanently closed, an opening must be made, and a small silver tube inserted, when the whole difficulty will be removed.

The *cushion of fat* which is situated at the bottom of the socket, serves both to keep the eye out in its place, and as a soft bed for it to rest upon; it prevents jars and allows the eye to turn with perfect ease. It is almost the last of the fat of the body to be used when a person is sick or starved, and hence sunken eyes are signs of great exhaustion.

The *muscles* of the eye are six in number, see title-page and fig. 198. There are four straight,

Fig. 198.

called recti, and one superior, and one inferior oblique. The straight muscles are about as wide and thick as common tape, arise at the bottom of the socket, and lead out to the upper, lower, outer, and inner parts of the eyeball, to which they are attached about as far back as the white can be seen. The superior oblique arises from the same place, and extending upward, it terminates in a round tendon, which passes round another short tendon called a pulley or trochlea, situated at the inner edge of the upper and nasal part of the socket. From this pulley it passes back to the upper, outer, and back part of the eye. The inferior oblique arises from near the unguis, and passes back to be attached to the outer, lower, and back part of the eye. The recti muscles move the eye upward, downward, inward, outward, between each of these directions, and of course rotate or roll



What are the meibomian glands? The puncta lachrymales? The lachrymal sacs? Where in the vicinity of the eye is fat found, and where not? Describe the muscles of the eye?

the eye. Strange to say, it is not yet agreed what is the use or effect of action of the oblique muscles. They are supposed to hold the eye forward, while the recti muscles direct its axis. The upper is also thought to roll the eye inward, and downward, while the inferior directs the eye upward, and inward. They are also supposed to keep the axis of the eye in the same direction, when the head is turned toward either shoulder.

579. The *eye* is constructed of three classes of parts. 1st. The expansion of the optic nerve, called the retina, which is presented to the action of light, and is the essential part. 2d. The transparent media through which the light reaches the nerve. 3d. The coats which sustain and protect the parts within.

580. The *coats of the eye* and their appendages, include the Sclerotic, Cornea, Conjunctiva, Choroid, Ciliary Body, Processes, Ligament, and Muscle, Iris, Jacob's Membrane.

The *sclerotic coat*, also called "white of the eye," is a white fibrous box, forming about $\frac{4}{5}$ of a hollow sphere. It is about $\frac{1}{16}$ of an inch in thickness, and exhibits two openings, one of which is small, posterior, and closed by the optic nerve, the sheath of which becomes continuous with the sclerotic, the other is large and anterior for the admission of light. The use of the sclerotic is for protection and the attachment of muscles.

The *cornea*, sometimes called the window of the eye, is a beautifully transparent, convex externally, and concave internally, lens, about as thick as the finger nail, composed of several layers, and fitted by its circumference to the edge of the anterior opening of the sclerotic, with which it is continuous. It appears like part of a small sphere attached to a larger one. Its use is to transmit and reflect the light which falls upon its surface.

The *conjunctiva* is the skin covering the anterior part of the sclerotic and the cornea, and the back surface of the lids. It is continuous with the lining of the nasal duct and fossa, and for the same reasons that a "cold" affects one it may affect the other, and often for the same reason why disease affects the mucous membrane of the digestive canal, it will affect the conjunctiva. Its inflammation has therefore various causes, and requires different treatment in different cases.*

* The washes sold by quacks should be carefully avoided. They may sometimes be harmless, occasionally beneficial; but their use must generally be injurious, and I have known cases where it has shut out the light for ever. Mere water is the safest and best ordinary application, warm or cold, as is most comfortable.

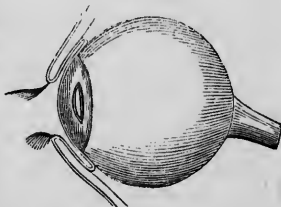
The *caruncula* is the name given to the small fleshy eminences at the inner corners of the eye. They are apt to grow out upon the cornea, and sometimes affect vision. If they are troublesome, they should be removed. Hairs sometimes grow out from them, and should be extracted.

Dust can often be removed from the eye, by simply drawing the upper lid down over the under one.

All the above parts are shown by the following figure.

The *choroid coat* is not as thick as the sclerotic, is composed of a few fibres, a great number of blood-vessels, and very many cells, those near its inner surface containing much pigment, and giving the choroid a beautiful dark brown appearance. It lines the sclerotic as far forward as within an eighth of an inch of the cornea. It adheres closely to the sclerotic at the position where the nerve enters, but by only a few fibres throughout the rest of its extent. Its use is to furnish blood to the eye, and present a dark surface for the absorption of light which has acted on the nerve.

Fig. 199,



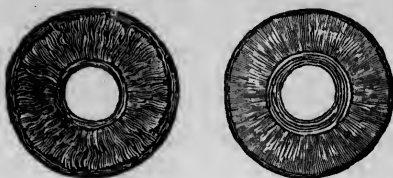
The *ciliary body* is the name given to that portion of the eye which extends from the choroid to the cornea. It is a continuation of the choroid which on one side adheres to the sclerotic, and on the other is formed into numerous folds which extend into the eye, and are called the ciliary processes. From these and the body in part, some grayish fibrous substance, called the ciliary muscle, extends towards the border of the sclerotic, near to which it terminates in a kind of tendon called the ciliary ligament.

The *iris*, or colored part of the eye, can be seen to be chiefly composed of sphincter and radiated fibres. They are muscular in nature. The first contract and the second dilate the pupil, which is the name given to the hole which exists in the centre of the iris. The circumference of the iris is attached to the ciliary ligament, body and processes. The front surface is composed of a serous membrane, which is continuous with that which lines the cornea. The back surface contains black pigment cells, and is called the uvea. See figs. 200 and 201.

The use of the iris is to regulate the quantity of light admitted to the nerve.

What classes of parts constitute the eye? What do the coats of the eye, and their appendages include? Describe the sclerotic coat? The cornea. What are the caruncula? Describe the choroid coat? What are the ciliary body, processes, ligament, and muscle? Describe the iris? What is its use?

Fig. 200 and 201.



All the above can be seen in section, in fig 2, Plate 8.

581. The *transparent Media* include the cornea, the aqueous humor, the crystalline lens and the vitreous

humor, composed of the hyaloid membrane and its contents.

The *cornea*, already described, is itself composed of three laminae, and covered by the conjunctiva, and lined by a serous membrane, yet they are all as transparent as the most pellucid crystal. Its use is to retain the humors of the eye, and powerfully refract the light, which it does more than any other part of the eye.

The *aqueous*, or water-like humor, fills the space between the iris and cornea, called the anterior chamber of the eye, and passing through the pupil also fills the small space back of the iris, called the posterior chamber. It is apparently secreted by the serous membrane of the cornea and iris. Its density is nearly like that of the cornea, and it affects the rays of light but slightly.

The *crystalline lens* is a double convex lens, the posterior surface being generally the most convex. It is composed of a fibrous transparent capsule, and a body which fills, but does not adhere to the capsule. The body is composed of fibres arranged in concentric layers, like the coats of an onion, the central ones being called the nucleus, and more dense than the outer ones. The light which passes through the central parts of the lens is refracted more than it would be if they were of the same density as the circumference. The lens is situated just back of the iris, sometimes touching it, and forms the back part of the posterior chamber. It varies somewhat in density from the aqueous humor, and of course refracts the light which enters it.

The *vitreous humor* occupies all the back part of the eye. It is composed of the hyaloid membrane and a watery fluid. The hyaloid forms its outer surface, and is in contact with the retina, and sends in processes which intersect each other, and form small spaces or areolæ in which the watery fluid exists. This humor is concave in front, and deeply receives the crystalline lens, to the

What do the transparent media include? What is the use of the transparency of the cornea? Where is the aqueous humor, and what is its use? Describe the crystalline lens? Describe the vitreous humor?

capsule of which it closely adheres. The hyaloid from the front surface of the humor, passes onto the front surface of the capsule of the lens, to which it adheres, leaving however a small space all round the lens at its edge or circumferential border, called the canal of Petit. The front surface of the vitreous humor near the lens, is indented or furrowed, to receive the ciliary processes, which adhere to this part of the hyaloid, which is called the ciliary zone.

The use of the vitreous humor is to fill the back part of the eye, support the lens and the retina, transmit, and perhaps modify the light which it receives.

582. The *retina* is chiefly composed of cells and fibres.

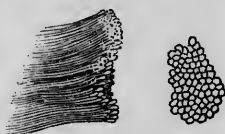
The *fibres* of the retina are thought to be the axis cylinders only, of the optic nerves, which after extending through the sclerotic, choroid, and Jacob's membrane, expand themselves upon the hyaloid membrane, as far as the choroid extends, presenting a concave, spherical surface to the light entering the eye, which was necessary.

Illus.—If a common lens or sun-glass is held before several candles at an equal distance from it, and a piece of paper be placed in the focus of all of them, it must be curved, see fig. 2, Pl. 8.

How the nerves commence in the retina is not known. Some think it is by loops, some think that the nerves blend into a common expansion, while others, and I believe correctly, think that the nerves commence by points exceedingly fine, which completely occupy the sensitive surface of the retina. As represented by fig.

202, an ideal view of a small portion, and also by figs. 1, 2, 3, and 4, Pl. 8. I believe this is the arrangement, because, 1st, there are points of exceeding delicacy very near to each other, too near to be distinguished by the naked eye, through which distinct sensations may be caused. 2d. The eye is also constituted, so as to cause light

Fig. 202.



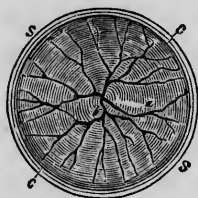
coming from different visual objects, to act on different points of the retina, from which there must, it would seem, be distinct means of conduction. 3d. In some animals, which have eyes with many facets and tubes accordingly, but no refracting medium of consequence, there is a distinct nerve to each tube. 4th. There is nothing observable in the structure of the retina, as yet observed, which weakens the opinion. But it is not certain. The practical results

Of what is the retina composed? Have you tried any experiment with a sun-glass and candles? How do the nerves commence in the retina? What does the author think in respect to this point?

are the same as if it were; therefore the figures have been made, and language used in consonance with the ideas entertained. But it must always be borne in mind, that when the point of a nerve is spoken of, nothing is with certainty meant except an impressible point through which a distinct sensation is caused.

The *cells* of the retina exist on its front surface next the hyaloid, and also compose a considerable portion of its back part, the appearance of many of them is similar to that of those forming the ganglia of the brain.

Fig. 203.



The retina is very plentifully supplied with blood. An artery called the centralis is situated in the centre of the optic nerve where it enters the eye, and immediately branches out in a beautiful arborescent manner in the retina itself, and connects with millions of capillaries in it. It can be seen by looking steadily at a white object, and moving a light about near to the eye; it will seem to be on the object.

583. The *nerve of sight* is called the optic or the second pair.

Apparently, the nervous filaments from the left halves of the eyes connect with the left brain, and those from the right halves with the right brain. Therefore, those from the inner halves must cross each other, which in part forms the commissure or chiasma of the optic nerves. The reason for this is seen, if it is observed that the light from any visual object acts upon the opposite of the retina from where it is; e g., an object to the right, acts on the left side of the retina, if the object is below, the upper part of the retina, &c.*

A line drawn from the point of the retina acted on and the visual object, as from r to R, in fig. 2, Plate 8, is called the *line of direction* of the object. When any object is in the right field of view, the line of direction will reach the left part of the retina, an effect through the nerves will be produced on the left brain, and by the

* I have seen it stated that the rays of light from an object crossed each other as they enter the eye, but this is a great mistake. Where they cross, is the focus, and it is an essential thing to correct vision, that they should not cross each other till they reach the retina. Rays from different objects, or from different parts of the same mental object, do cross, but this has nothing to do with seeing.

What in this book is meant by a point of a nerve in the eye? Have you tried to see the artery of the retina as suggested? How are the filaments of the optic arranged? What is the line of direction of objects?

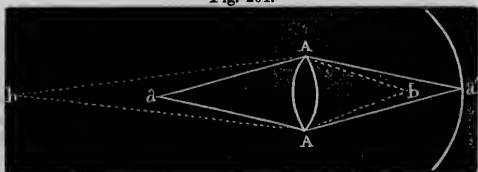
crossing of the fibres in the medulla, an influence can be exerted upon the right side, when the right hand may be thrown up and the threatened danger warded off.

584. The *uses of the eye*, are to cause the light received from different visual objects to act intensely on different points of the retina, and produce simple impressions.

The office of the eye is very simple, much more so than is usually thought; the sensations are caused by the action of the sensorium, and the idea of the direction of objects, and the corresponding of the sensations, and the knowledge of the qualities of objects gained through the eye, are all dependent upon mental action. When, therefore, pressure on the eye causes a sensation to be produced, the cause not only seems to be light, but it seems to have a certain direction; when, also, the circulation of the blood in the arteria centralis, or any other cause, produces sensations of specks or "wiggles," they seem to be before the eyes.

But fig. 204, shows a fact of importance, viz., that with the same lens A, if the object be at a, the light will be brought to a different focus

Fig. 204.



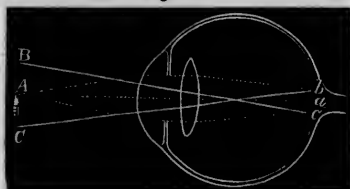
from what it will be if the object is at b. The eye is curiously constructed, so as to be adapted to seeing objects equally well at all ordinary distances. But what changes it undergoes, is not yet certain. Some have supposed that the muscles of the eye compressed it, so as to make it longer when near objects are observed. Some have thought the lens was increased in density in such cases. Some have thought that the cornea was distended or flattened. Others have thought that the position of the crystalline is changed forward and backward by the action of the ciliary muscle, which, of all conjectures, is the most probable.*

* I have seen it stated that the modification of the eye was produced by a change in the inclination of the lens. The idea is almost too ridiculous to notice; for if the inclination of the lens were in the least changed, it is evident that no perfect focus could be obtained of the light from any two objects, viz., a person could not see at all.

What are the uses of the eye? Where do all sensations of sight seem to be? How is the action of the light coming from objects at different distances represented by fig. 204?

Some eyes never possessed, or have lost, the power of adaptation. If objects can be seen only when they are near, the eye is called near-sighted; if they can be seen only at a distance, the eye is called long-sighted. But the eye is no more near-sighted in one case, or long-sighted in the other, than any good eyes. The difficulty is, it is not long-sighted in one case, and not short-sighted in the other, while good eyes are both. The reasons for the obscurity of vision are three-fold. Fig. 205 represents a long-sighted eye acted upon by light from a single point, but the light not being brought

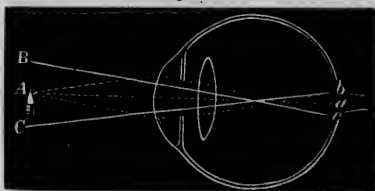
Fig. 205.



to a focus, acts over the nerves from *b* to *c*. The natural line of direction, when the nerve *c* is acted on is *cB*, and if the eye were perfect, and the nerve *c* were acted upon, an object would be found at *B*; and if *b* were acted upon an object would be at *C*; and if all the nerves between *b* and *c* were acted on, there

would be objects at all the points between *C* and *B*. But the impressions are made on all the nerves between *b* and *c*, and the sensations are naturally, though not intensely produced; hence it seems to a person with such an eye, that the light occupies all the space between *C* and *B*. If the old lady try to snuff the candle, she will perhaps snuff the wick the first time, and perhaps the twentieth time trying. So she attempts to thread her needle all round where its eye really is. Fig. 206 represents the short-sighted eye, the nerves of which are in the same way affected, though from a different

Fig. 206.



cause, and the result is the same; the candle seems to the person to occupy the space between *B* and *C*, the central part of the space being very bright, and the circumference more and more dull. So when the telescope slide is moved out, or in, beyond the point of distinct vision, similar obscurities are caused. This also shows the simple action of the eye, and the part it takes in

What is the defect in long-sighted eyes? What is the defect in short-sighted eyes? Describe figs. 205 and 206.

vision, and that the idea of the direction of objects is constitutional, for experience has not corrected the erroneous impression of the old lady about the position of her candle; and the older she grows, the worse it will be. Another cause of obscurity is shown by figs. 3 and 4, Plate 8. The fact is exaggerated to make the idea clearer. It is there seen that the light from different objects acts upon the same nerves, which at once destroys all distinctness of vision, and produces confusion.

The cause of this disability of long and short-sighted eyes, as they are improperly called, is not known. Long-sightedness is frequently attributed to a flattening of the cornea as age advances, but a majority of persons who are short-sighted have become so after the age of a dozen years, and usually by study, and neglecting to use the eyes much for long sight; so that it would seem that disuse of some visual power enfeebled it. Short-sightedness may be prevented, and many times remedied, by using the eyes to look at distant objects frequently. How to ward off long-sightedness I know not. It is usually remedied by the use of convex glasses, as short-sightedness is by concave ones. I am, however, acquainted with several persons who are short-sighted, and yet can see distinctly only by wearing convex glasses. I can only account for this, by supposing that their nerves are very sensitive, and therefore the light of near objects is scattered over the adjoining nerves, so that confusion is produced; or there may be undue reflection in their eyes, producing the same result, and the use of convex lenses has the effect to throw the light from objects more intensely upon points of the retina which are also more distant from each other.

The effect of microscopes illustrates the same subject, and also shows that the line of direction is judged of instinctively. The effect of the microscope is to cause the light of objects which, in the natural eye, would be received upon the same nerves, to fall at quite a distance from each other on the retina, and the more distant, the farther apart do the visual objects seem to be, and of course the larger does the mental object appear.

The distance of objects, when seen, seems to be determined by the judgment based upon experience; e. g., if an object be observed, and while the eye is turned, diminished in size, when viewed again it will appear farther off; as usually a mental object which appears large is near, and vice versa.

The reason why objects appear to be single is because, though

What is shown by fig. 344, Pl. 8. What may be done to prevent or improve short-sightedness? How does the microscope magnify objects? How should the eye be treated in order that it may be healthy?

the light from them acts through both eyes, it acts on corresponding points of them, and the apparatus is so constituted, that in this case only a single sensation will be caused. If one eye be pressed on one side, two objects will at once appear where only one appeared before, since the light does not act on corresponding points. Persons who are cross or wall-eyed, see double, except as experience allows them to only pay attention to the sensations caused by one eye. Again, where the nerve enters the eye there is a central point where nerves do not commence, and through it sensations cannot be produced; e. g., if, with the left



×

eye closed, the adjoining dot be observed with the right eye, and the book moved

toward the eye with its lines parallel to the axis of the eyes, the cross will vanish and again appear as the book approaches the eye more nearly, which shows that there is some point of the retina which, when acted upon, does not cause sensation. At all times this point is acted upon by the light from some object, but the sensation produced through the other eye is not less intense than usual, nor is the mind confused in respect to its judgment of the line of direction or distance of that object.

The eye is also so constituted as to avoid the effect of chromatic aberration. It will be seen by fig. 7. Pl. 8, that blue light is refracted more than yellow or red, and this would be the case in the eye, producing confusion, did not the transparent media of the eye correct the difficulty,—precisely how is yet a an unanswered question of importance.

But the light which passes through the circumference of an ordinary lens is refracted more than that which passes through the central part, producing what is called spherical aberration. This evil is mostly avoided in the eye, partly by the greater density of the central part of the lens, partly by the action of the iris, which prevents light from falling very near the circumference of the lens.

585. To *preserve the eye in health* it should be actively used and allowed proper repose. It suffers with the general health of the body, and improves with it. It is one of the most pleasure-causing of all the organs of sense, and the healthful influences of light upon it are diffused throughout the body.

What is the effect of pressing on the eye? Are all points of the retina equally im-
pressible? Is the eye acromatic? Do all the rays of light which from one visual
object enter a perfect eye, act on a single point of the retina?

Many persons live in too dark apartments, or with blinds of a single color, and feel too much the influence of only one kind of light. If glasses be worn for weakness of the eyes, those which are gray, and exclude a portion of all kinds of light, will usually be better than those which exclude only one kind and freely admit the others.

CHAPTER V.

Sensation of Hearing and its Organs.

586. *Sound*, or the sensation of hearing, is the name given to the sensations usually produced through the auditory nerves.

587. The *uses of the sense of hearing* are to inform the mind in respect to the direction, distance, and qualities of objects; to startle the mind when danger is impending, to arouse it for the defence of the body, to excite it to relieve distress, and indeed to excite many of the emotions, and to produce mental happiness and physical health.

Many sounds are therefore unimportant, and should produce no very decidedly pleasant or unpleasant sensations; while others should be disagreeable and irritating. It would also be improper to arouse the mind without the body was also put in a state fit for instant use by the mind; while therefore the sensation is caused in the mind, the body is involuntarily acted upon through the organs of this sense. The health of the body as well as that of the mind is powerfully influenced through the ear. The utility of music is doubtless something more than the pleasurable sensations it causes. Indeed, the reason why they are so pleasurable is, probably, because the influence of music is so profitable to the health of the body and mind.

588. The *organs of hearing* include the auditory parts of the brain, the auditory nerve and the ear.

How should the eye be treated, in order that it may remain healthy? What is sound? What are the uses of the sense of hearing? Does the state of the nervous system which produces the sensation of hearing, produce any effect on the body?

589. The *object* which acts on the ear, is the air thrown into waves or impulses by the action of various things, which are also called objects causing sound.

Almost every object in nature has the property of acting peculiarly upon the air, and producing in it peculiar waves or impulses, which it is the duty of the organs of hearing to distinguish. This influence upon the air may be exerted either by wavy vibrations, or by impulses, or oscillations.

Any irregular impulse of the air will cause a *noise*, while regular impulses cause a *musical sound* to be produced through the ear, in respect to which three things may be noticed. 1st. The *pitch* depends on the rapidity with which vibrations are caused. 2d. The *intensity* or *loudness* depends on the violence and extent of the impulse which acts on the ear. 3d. The *quality* is supposed by Herschel to depend on the abruptness of the impulses.

Inf. If this be at all correct, it is of great importance, since abruptness can be controlled, or at least qualified by cultivation of the voice and mind.

The quality of the sound is not, however, altogether dependent on its degree of abruptness, but upon I know not what. All kinds of impulses move with equal rapidity, since music has the same time at a distance and near by.

Waves of air like waves of water, are always partly reflected by any solid body against which they act. The waves thus reflected have a different direction from the original ones, and cause the sound called an echo, which so far as the ear is concerned, is produced in the same manner as any sound. But as waves grow less with the distance they pass through, their effect will be feebler; hence the echo will be feebler than its antecedent.

590. The *ear* is composed of the external, middle, and internal ear.

The external ear is composed of the pavilion and meatus. The pavilion exhibits a rim called the helix, and a lobe below at its circumference. Another rim within, is called the anthelix. A concavity at the upper part is called the scaphoid fossa, and a deep one below is called the concha, in front of which is an eminence called the tragus, and opposite to which is the antitragus.

What acts on the ear, when a sound is naturally produced? What is a noise? What is a musical sound? How can the quality of sounds be improved? What is an echo? Of what parts is the ear constructed?

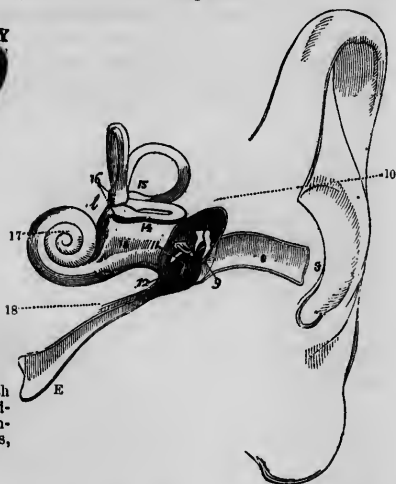
Three small muscles extend from the pavilion to the skull. Their use is to move the pavilion. Its use is to reflect and transmit

Fig. 207.*

Fig. 208.



207,* represents the labyrinth very much magnified, V, vestibule, O, foramen ovale, R, rotundum, X, Y, Z, semicircular canals, K, cochlea.



the vibrations of the air. The *auditory canal* (8, fig. 208,) leads inward and slightly downward from the concha to its blind extremity. It is partly cartilaginous and partly bony, lined with thin skin, and closed with it at its deepest part. Its sides are furnished with ceruminous glands, which secrete the ear-wax. Sometimes this becomes dry. A little oil dropped in the ear and retained by a plug for a few hours, will soften the wax, when it can be removed by castile soap and warm water.*

Fig. 208 represents the ear. It should be remembered that the inner ear, which is here and elsewhere represented as isolated, is, in fact, in the midst of bone, which is indeed part of it. Here is represented only the more solid portion of the bone which directly forms the ear; 8, auditory canal; 9, membrane of the tympanum; 10, drum containing the bones of the ear; 12, foramen rotundum; 11, promontory; 13, over the opening into the vestibular scala; 14, 15, semicircular canals; 16, ampullæ; 17, cochlea; 18, canal by the Eustachian tube for tendon of tensor muscle.

* The ear oils etc., sold at the shops as a sure cure for deafness, are, of course, the most barefaced impositions. For any desirable object to be gained by oils, common sweet oil is the best. Ether is sometimes used for the same purpose.

Of what is the external ear constructed? Describe the auditory canal. Describe figs. 207, 208. What is said of ear oils?

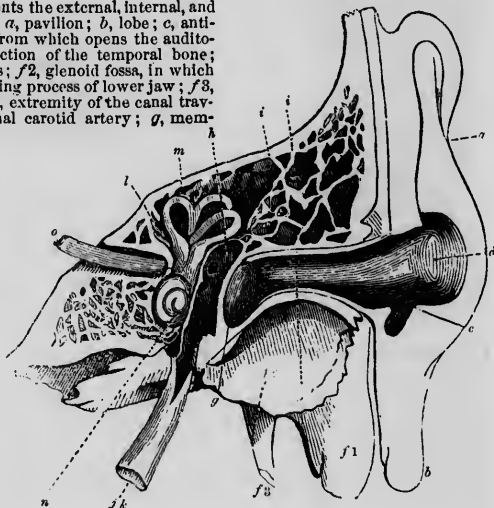
The auditory canal serves merely as a conductor of vibrations.

The *middle ear*, also called the tympanum or drum, is a cavity about the size and form of a kidney bean. It is situated just at the inner extremity of the auditory canal, being excavated from the petrous portion of the temporal bone. A tube about as large as a straw commences at the lower part of the drum, and leads down, and opens trumpet mouthed into the back part of the nasal fossa. It is called the Eustachian tube (E, fig. 208). It serves the double

Fig. 209.

Fig. 209, represents the external, internal, and middle ear, in situ; *a*, pavilion; *b*, lobe; *c*, anti-tragus; *d*, concha, from which opens the auditory canal; *e, f, f*, section of the temporal bone; *f1*, mastoid process; *f2*, glenoid fossa, in which moves the articulating process of lower jaw; *f3*, styloid process; *f4*, extremity of the canal traversed by the internal carotid artery; *g*, membrane external of the tympanum; *h*, tympanum; *i*, openings into the mastoid cells; *j, k*, Eustachian tube; *l*, vestibule; *m*, semicircular canals; *n*, cochlea; *o*, acoustic or auditory nerve.

In this representation the bony tissue is seen to increase in density near the parts of the middle and internal ears. The more solid parts being those which are usually considered to belong to the ear itself.



purpose of allowing the air to pass backward and forward, and the mucus, or any substance, to pass down from the drum and openings communicating between the drum and the mastoid cells. In the bony walls of the drum, there are also three other openings; one leads into the auditory canal, which, as already said, is closed by the skin, within and upon which, a fibrous structure is found, stretching across the opening from the tympanum. It is called the external membrane of the tympanum, or the outer drum-

What is the use of the auditory canal? What is the middle ear? What is the use of the Eustachian tube? How many openings are there in the walls of the drum? What is the membrane of the tympanum?

head; (9, fig. 208.) Its use is to transmit the vibrations of air which act upon it. At the opposite side of the drum, two holes may be found; one being round, is called the rotundum; the other being oval, is called the ovale. They are both closed by fibrous structures like the one just described. They are also called the inner heads of the drum. Their office is to transmit the vibratory influences they receive.

Across the drum four* bones stretch from the external membrane to the foramen ovale (fig. 208.) The 1st is called the malleus, or hammer; 2d, the incus, or anvil; 3d, the orbicularis, or round bone; 4th, the stapes, or stirrup. These are all jointed, and furnished with cartilages, ligaments, and synovial capsules.

The use of these bones is to transmit vibrations. Two delicate muscles also exist in the drum; one extends from a canal by the side of the upper part of the Eustachian tube to the malleus, and when it contracts by drawing that bone inward, it makes the external membrane tense; hence its name, tensor membrana tympani. The stapedius muscle extends from within a conical eminence called the pyramid, to the stapes, and by contracting assists to make its membrane and the whole chain of bones tense. The other delicate structures, sometimes called muscles, are probably not so. The whole of the Eustachian tube, the drum, and the mastoid cells are lined with mucous membrane, which also covers the bones of the drum. The mucus it forms passes down into the nasal cavity. It is liable to be affected when "colds" are taken, especially the lining of the tube, which causes "hardness" of hearing, or deafness.

The *internal ear* is also called the labyrinth. It is composed of the vertebræ, three semicircular canals, and the cochlea. The vestibule is an irregular cavity, which is in connection with the membrane of the foramen ovale. Out of it open the three semicircular canals by five openings, as two of the canals unite at one extremity. The cochlea has, externally, something the appearance of a snail-shell. Internally, the cochlea is divided by a lamina, partly bone, partly ligament, and partly muscular. The cavities thus formed are called scala; one the vestibular, since it opens from the vestibule, and one the tympani, because it opens against the foramen rotundum of the tympanum. The scalæ communicate at the top of the cochlea. The axis of the cochlea is

* Some of our best authors make but three bones, the orbicularis being considered as part of the 2d.

What is the office of the foramen, rotundum and ovale? What are the names of the bones of the ear? What is the use of the bones? What is the use of the internal muscles of the ear? How can colds affect the ear? Of what parts internal ear composed?

called the modiolus and contains many orifices for the nerves.

Fig. 210.



The whole labyrinth is lined with a very delicate serous membrane which secretes a serous fluid called the perilymph.

Fig. 210 represents the membranous labyrinth, and the nerves terminating in it. 1, 2, 3. Ampullae. 4, Common canal. 5. Utricle. 6. Saccule. 7. 7th nerve. 8. Branch of the 8th, leading to 10, ampullae, and 11, to the otoliths of utricle. 12. Branch of 8th nerve terminating in 13, the saccule and its otoliths. 14. Branch extending to the cochlea.

The vestibule and semicircular canals contain what is called the membranous labyrinth. It is a membrane forming in the vestibule two communicating sacs,

one called the utricle, the other the saccule, and extending through the semicircular canals, being of the same general form as the bony parts in which it is, but only a third as large. It connects with the lining of the bony labyrinth only where the nerves enter. It has a free cellular surface both within and without, and is filled with endolymph, and surrounded by the perilymph. The vestibular portion contains a crystalline powder, which proves to be carbonate of lime, and called in this place otoliths. The use of particular parts of the labyrinth is not known; as a whole, it has the office of transmitting the vibrations of the membranes of the drum to the auditory nerves.

The *nerve of hearing* terminates or commences in the labyrinth, how, is not known. Some think by loops, and some by minute points. They appear to terminate in the saccule, utricle, ampullae, and in the lamina spiralis. (See fig. 210.)

What is the vestibule? What are the semicircular canals? What is the cochlea? What is the perilymph? Describe fig. 210. What is the membranous labyrinth?

Fig. 211.



Fig. 212.

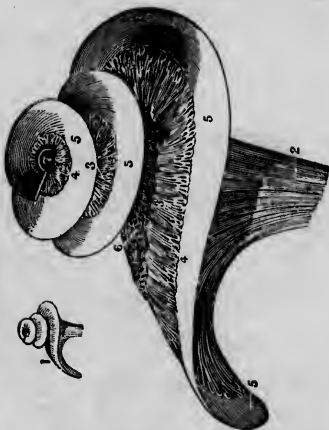


Fig. 211 represents nerves very much magnified, terminating by loops in the ampullæ.

Fig. 212, 1, natural size of, 2, nerves in the modiolus and curving out; to terminate in the lamina. 3; 4, edge of the bony portion; 5, membranous portion; 6, bony lamina; 7, cupola.

Some of the nerve filaments seem to pass into the sacs, and become attached to the otolithes.

591. The essential things for hearing are the nerves and labyrinth, in which their outer extremities are supported and acted upon.

Fig. 213.

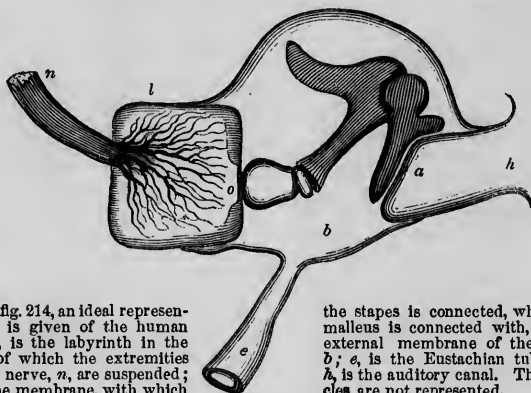


Fig. 213 represents what is seen in some of the lower animals; *h*, the auditory nerve terminates in *b* the saccule; *a*, *g*, the utricle; *f*, ampullæ; *c*, *e*, *d*, semicircular canals. Here are the membranous labyrinth and nerves alone, yet hearing is produced.

What are the otolithes? How do the nerves of hearing commence? What things are essential to hearing? Describe figs. 211, 212, 213.

Some animals have only a sac, with a few otolithes and nerves connecting with them.

Fig. 214.



In fig. 214, an ideal representation is given of the human ear; *l*, is the labyrinth in the fluid of which the extremities of the nerve, *n*, are suspended; *o*, is the membrane, with which

the stapes is connected, while, the malleus is connected with, *a*, the external membrane of the drum, *b*; *e*, is the Eustachian tube, and *h*, is the auditory canal. The muscles are not represented.

Whatever waves of air act on *a*, must cause an effect to be produced on the nerves in *l*; thus an impression is made on the nerve, and through it a sensation is produced in the mind.

592. The *middle and external ear*, are only means by which the effects of the vibrations of the air are directed upon the nerves.

593. The *sensations of hearing* are of a very simple character, and all the knowledge of the directions and distance of objects causing sound, are the result of mental action.

Inf. Composed of so many parts, the ear must be liable to many different kinds of disease, which would be difficult to cure, and require very skilful treatment.

Colds are the most common cause of deafness; next to that cause, scarlet fever is the most frequent. In case of which, it is usual that the patient has taken cold.

What is the simple condition of the ear in some animals? Describe fig. 214. What is the use of the middle and external ear? How do we know the direction whence waves of the air have come? What is one means of avoiding hardness of hearing?

When obtuseness of hearing has occurred, one of the most judicious things for its removal is to be very careful not to take cold.

594. As in case of all the organs of sense, use, or exercise, improves those of hearing wonderfully.

Improper use of them will sometimes derange the nerves or brain, so that "ringing," "singing," and other sounds, will be very unpleasantly felt in the head, though such sensations usually arise from some other cause, there being many which affect the brain, so that noises will be heard.

595. In *case of sickness*, these organs of hearing have many times a very important effect; the slightest wave of air, or noise as it is called, producing discomfort and aggravating the disease.

Inf. Extreme quiet should be preserved.

These facts show that the organs of the sense of hearing can exert, by their connections, a very powerful influence both upon the body and mind.

CHAPTERS VI. & VII.

Muscular and Internal Senses and their Organs.

Muscular sensations are names given to those which arise from the action of the muscles, the organs of the muscular sense. Internal sensations have their primary cause in the health, disease or wants of all parts of the body, which are organs of the internal senses. These may be classed as senses of hunger, thirst, suffocation, &c. How the organs of these senses act on their nerves is an enigma. Collections of blood or matter, when confined by fibrous tissue, seem to cause pain by pressure, as in felon, whitlow, boils, etc., which is at once relieved by *deeply* and *thoroughly* lancing the part. This cannot be, however, the general mode of action when internal sensations are caused. For the muscles cause most annoying sensations to be produced when they are not active at all. The peculiarities and uses of these sensations, may be best treated upon in connection with the parts which cause them.

What improves the organs of hearing? What is necessary in case of sickness if sounds are painful? What are muscular and internal sensations?

REVIEW OF BOOK I.

A philosophic view of the grand, apparently complex apparatus of Relation, resolves it into several simple classes, each part of which is most admirably adapted to a particular purpose. A frame-work of light, strong bones, cartilages, ligaments and synovial membranes, present ample surfaces for the attachments of the muscles. A great nervous centre holds communication with the external world, by means of the organs of sensation, and control over the muscles by means of the motor nerves; while it furnishes the means of action for all the mental powers. But while the action of each part is for a particular purpose, the result of their combined action is single, viz., the development of the mind, and however important any action in itself may seem, it will be found to centre at this important focus. Mental requirements are different, at different periods, so is the apparatus of relation adapted to different kinds and degrees of activity, at the different ages.

Its life and health consists in activity and change of parts, which to a greater or less degree are constant during life, no change being followed by the same state of things as that which preceded it. These changes are partly inherent in the constitution of the body, and therefore necessary, and partly produced by the mind, and world. An education of every mind must therefore be constantly going on. It is of four kinds; of the senses, emotions, intellect, and motor powers. Education of the senses requires their use. Education of the emotions requires their activity, they are not merely to be read or talked about, but to be felt. Intellect is educated by observing, feeling, reading, conversing, and thinking. The motor powers can be educated only by practice. A complete education embraces an education of each kind in a *natural manner*, and in proper proportion.

The Creator has adorned the world with beauty, that it may act favorably upon the mind, and assist in its refinement.

The true happiness of every man is dependent on that of his fellow-men, and the high cultivation of all those emotions and intellectual characteristics which bless mankind by their activity.

The child should be early taught to notice and love the exquisite pleasure which converse with nature's works alone can give.

"There is a pleasure in the pathless woods,
There is a rapture on the lonely shore,
There is society where none intrudes,"

Neatness and comfort should prevail in every dwelling. Nature should be improved by art, and universal education made to produce an exalted equality among all men.

BOOK II.

APPARATUS OF ORGANIC LIFE.

"My heart is awed within me when I think
Of the great miracle that still goes on
In silence round me—the perpetual work
Of thy creation, finished, yet renewed
For ever. Written on thy rocks I read
The lesson of thy own eternity.
Lo! all grow old and die—but see, again,
How on the faltering footsteps of decay
Youth presses—ever gay and beautiful youth
In all its beautiful forms. These lofty trees
Wave not the less proudly that their ancestors
Moulder beneath them. Oh, there is not lost
One of earth's charms; upon her bosom yet,
After the flight of untold centuries,
The freshness of her far beginning lies,
And yet shall lie. Life mocks the idle hate
Of his arch-enemy, Death—yea, seats himself
Upon the tyrant's throne—the sepulchre,
And of the triumphs of his ghastly foe
Makes his own nourishment."—BRYANT.

The above beautiful quotation is no more true of the world around than of that within. Asleep or awake, the whole organization of man is experiencing the most rapid changes. Death and life are constantly succeeding each other in every part of the body. The physical man of to-day was not yesterday, and will not be to-morrow, precisely the same. The action of the system requires the preservation of a proper temperature in every part while it is necessarily attended with decay, and repair must succeed, or exhaustion of the system will soon follow.

596. The *organic apparatus* is the name given to that grand class of apparatus by means of which the body is kept in a proper state for action. It includes the circulatory, the respiratory, the digestive, and the eliminatory apparatus.

All these parts are grouped by means of nerves, and connected with those centres which cause the action of the members of each group, to be harmonious with the wants of each part, and the whole of the body.

DIVISION I.

Circulatory Apparatus.

ANALYSIS.—*General character of circulatory apparatus—Two hearts—Each heart constructed of an auricle and ventricle—Situation of heart—Uses—Effects of its contraction—Composition and situation of arteries—Two classes, systemic and pulmonary, their uses—Structure and situation of capillaries—Use—Structure of veins—Three classes, pulmonary, systemic and portal—Use—A single circuit—Its use—Forces which circulate the blood—Lymphatic system, composed of vessels and glands—Two classes, systemic and lacteal—Uses—Closed Glands.*

597. The *human circulatory apparatus*, strictly speaking, consists only of complete tubular circuits, furnished with muscular and elastic tissue, and in addition at proper intervals with valves, the whole of which is admirably adapted to circulate blood with great rapidity through every part of the body. But it may very properly be said to include all vessels in the body through which fluids are moved, and also those parts which are appendages of the blood-vessels only. This division should, therefore, embrace four chapters; the first should treat upon those parts directly concerned in circulating the blood, viz., the hearts, arteries, capillaries, and veins. The second should consider the blood, and the causes and rapidity of its circulation. The third should describe the lymphatic system. The fourth should discuss the character of the closed or sanguineous glands.

CHAPTER I.

Hearts, Arteries, Capillaries, and Veins.

598. *Heart* is the name given to any serous sac, or pouch, surrounded by muscular substance, which by expansion and contraction can assist in circulating any fluid in the body.

It is not essential that the heart have any particular form. This varies in different cases. Sometimes it is simply a tube. Neither is it necessary that its action should be exerted upon blood, for there are lymphatic hearts.

599. In the human system *heart* is the name given to the serous and muscular pouches, by the expansion and contraction of which, the blood is received from the veins and driven into the arteries.

It is about the *size* of a man's fist, and in *form* corresponds to the hearts of our common animals. Its *surface* is formed by a serous membrane, upon which a serous fluid is continually poured to lubricate it. In *structure* externally, it appears to be a unit, but internally it is found both in structure and use, to be a double serous pouch, each of which is surrounded by its own muscular fasciculi—while both are surrounded by an outside coat of fasciculi, which spirally curve from the tip to the base, and the whole is enveloped by the external serous coat.

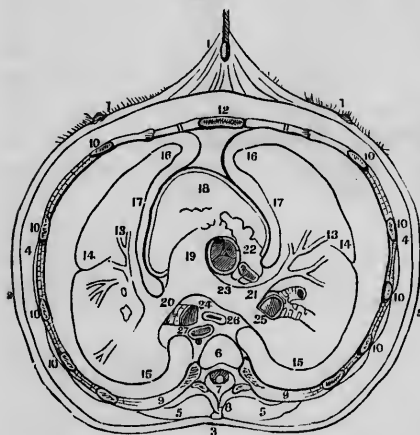
600. There are, therefore, *two human hearts*, called the right and the left, or the pulmonic and systemic; each of which is composed of two parts, the upper, called the auricle, and the lower, called the ventricle, between which are valves called the tricuspid, in the pulmonic, and the mitral, in the systemic heart.

The *auricle* is in more than one sense an enlargement of a vein, with muscular substance added between its coats. The amount of it is not great, and the action of the auricle is not strong. The *ventricle* has thick and strong muscular walls, and exerts corresponding power.

The auricles of each heart are very similar, but the systemic ventricle is much the stronger, since it must move the blood so much farther, and through difficult passages. The valves are formed of two layers of the serous coat, with fibrous tissue between them to give strength. Just where the opening from the auricle into the ventricle exists, the serous coat is prolonged and hangs into the ventricle. In the course of a short distance it is divided into three parts in the right, and two in the left heart. Each of these is again divided and subdivided, till the border of the valve seems to be composed of many small tendons, which extend across the ventricle, and become continuous with its muscular prominences, called *pillars*, and which, by contraction and relaxation, keep the

valves precisely where they should be. The *use of these valves* is to allow the blood to flow from the auricle into the ventricle, but not back again. In the pulmonic heart, however, the valves do not quite close their opening, especially when the heart acts with great power, or if there be some obstruction to the free flow of the blood through the lungs; for then a portion of the blood should flow back into the systemic veins, otherwise the lungs will be over-charged and injured. But the mitral valves close their opening completely, as no blood should be allowed to flow back into the delicate lungs. The *muscular filament* is mostly of the striped variety, which is an exception to the general rule in respect to involuntary muscles. The heart is surrounded by a heart-case, called the *pericardium*. It is a serous membrane, continuous with the outer one of the heart about its roots. In one sense it forms a second envelope for the heart. Its surface towards the heart is free, and always lubricated. The other side of the pericardium becomes continuous with the areolar tissue, which at the

Fig. 215.



same time separates and joins it to surrounding parts. The heart is *situated* a little to the left of the centre of the chest, between the lungs. See 18, fig. 215.

The *tip of the heart*, which is its lower and extreme left point, is situated against the space between the cartilages of the sixth and seventh ribs, and near the sternum. It is neither so low nor so far to the left side as many suppose. The pericardium rests

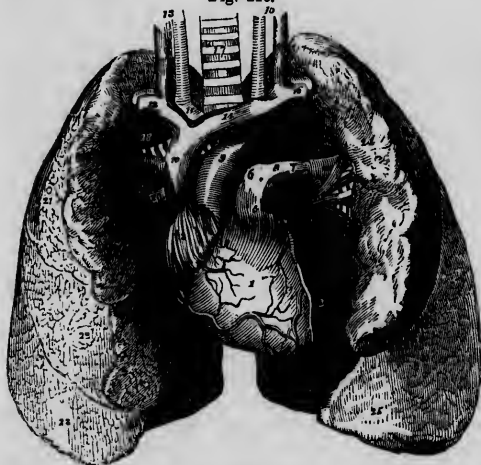
upon and adheres to the diaphragm. The heart is sustained by the

Fig. 215 represents a transverse section of the chest on a level with 18, the heart; 15, 16, 17, lungs which are collapsed, viz., do not fill the chest as when it is closed; 1, 2, 3, external integument; 4, 4, areolar tissue and fat; 5, spinal muscles; 6, body, 7, canal, 8, spinous process of a vertebra; 10, ribs; 12, sternum; 13, divisions of blood-vessels; 14, division between lobes of the lungs; 20, 21, pulmonary veins; 22, commencement of aorta; 23, vena cava; 24, 25, divisions of the windpipe; 26, œsophagus; 27, aorta.

ligamentary cords which connect between it and the spinal column.

601. The *use of the auricles* is to receive the blood, and by gently contracting, to pour it into the expanding ventricle. The use of the ventricle is to receive blood from the contracting auricle, and pour it out into the arteries.

Fig. 216.



Inf. The contraction and expansions of the two parts of each heart must alternate with each other.

The auricles contract together, and so do the ventricles; but while the former are contracting, the latter are expanding, and vice versa. Three eighths of the time is occupied by the auricles, and four-eighths by the ventricles, in contracting, which allows five-eighths of the time to the auricles, and four-eighths to the ventricles for repose.

602. The *rapidity* with which the contractions of the heart are produced, vary in different persons, and in the same person at different times. The average in this country is 73, or 74, in men, and 77, or 78, in females per minute.

I have known the pulse as low as fifty in youth and health, in one case, and as high as 100, in another.

Fig. 216 represents the heart between the lungs, 1 right, 2, left ventricle; 3, right, 4, left auricle; 5, 6, 7, 8, pulmonary artery; 9, aorta; 10, vena cava descendens; 11, arteria innominata; 12, right subclavian vein; 13, jugular vein and carotid artery; 17, trachea; 18, bronchi; 19, pulmonary vein; 20, pulmonary artery; 21, upper; 22, middle; 23, lower lobe of right lung.

603. The *effects of the contractions* of the heart are, 1st, corresponding decomposition of the heart; 2d, sounds very easily perceived, if the ear is applied to the chest; 3d, the throbbing of the heart against the sides of the chest; 4th, the pulsations of the blood in all parts of the body; and 5th, the regulation of the quantity of blood in all parts of the body.

604. The *contractions are influenced* by every part of the body, and by every state of the mind.

Since the heart is a ministering agent to all parts, it must act in accordance with their wants; hence it is intimately associated with all parts by means of the nervous system, and with the mind in particular, that with every rising emotion its action may correspond. There is not, probably, any organ in the body which feels the effects of nervous action so sensitively as the heart; and it is frequently overpowered by the intensity of the action upon it.

Arteries.

605. *Artery* is the name given to any vessel, the sides of which are in part composed of yellow elastic fibres.

Their use is to resist to a degree the distensive action of the fluid, forced into them, and by reacting upon it, assist in moving it along. They will, of course, be needed wherever fluid is forced into any vessel—and of course are always found leading out from sanguineous hearts. In the lymphatic vessels which receive the blood from the lymphatic hearts, I believe some elastic fibrous tissue can be detected, and such vessels therefore resemble arteries, but the action of those hearts is so gentle, that the arterial character should not be very decided.

606. Arteries are composed of three coats,—an internal serous, a middle elastic, and an external white fibrous, and are furnished with valves where they are connected with hearts.

The internal serous is continuous with the inner coat of the heart. The middle is mostly composed of yellow elastic fibres. The external tunic is composed of white fibres, which blend with the surrounding areolar tissue. The valves are composed of two thicknesses of the serous coat, with fibrous tissue between. They are three in number, and as there is no objection to having all the contents of the heart passed through and retained beyond them,

they perfectly close the opening about which they are situated. They are called semilunar, on account of their form. See fig. 2, Plate 7, and are so arranged, that the side of each overlaps its left neighbor, when they are shut down; when they are thrown up their edge is not perfectly in contact with the side of the artery, so that the reacting blood will pass behind the valve and close it. These valves are therefore opened and closed by the action of the blood itself.

607. Human *arteries* are divided corresponding to the hearts, into two classes, one called the pulmonary, the other the systemic.

In different animals the number of hearts and classes of arteries vary very much, as the following ideal figures show.

Fig. 217.

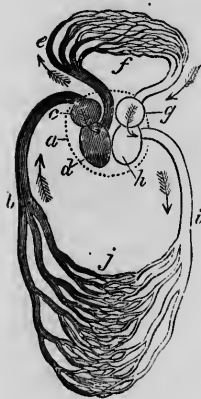


Fig. 218.

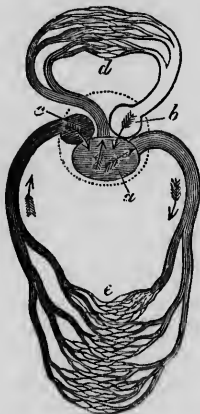


Fig. 219.

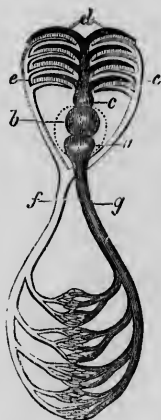


Fig. 217, is an ideal representation of the heart, arteries, and capillaries in man, and the higher classes of animals, as is also fig. 3, Pl. 5; *d*, right or pulmonary ventricle; *b*, left or systemic ventricle; *c*, right auricle; *g*, left auricle; *e*, pulmonary artery; *i*, systemic artery; *h*, systemic vein; *j*, systemic capillaries; *f*, pulmonary capillaries; *a*, serous membrane of the heart.

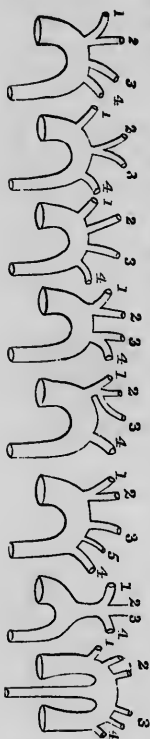
Fig. 218, represents the circulation of reptiles, *a*, ventricle; *b*, *c*, auricles; *d*, pulmonary, *e*, systemic capillaries.

Fig. 219, represents the circulation of fishes, *a*, auricle; *b*, ventricle; *c*, artery; *d*, *e*, pulmonary capillaries; *f*, dorsal artery; *g*, vein.

In some animals there is no particular pouch, but in many parts of the arteries a pulsation is seen which indicates a heart-like action.

The *pulmonary artery* rises for a short distance from the sum-

Fig. 220.



mit of the right ventricle, and then divides into two branches, which extend each way to the bronchi, near the surface of the lungs; as often as the windpipe divides the artery does, following the divisions to the capillaries which exist in the sides of the air-cells in which the bronchi terminate.

The *systemic artery* rises from the summit of the left ventricle, where it is called the as-

Fig. 221.

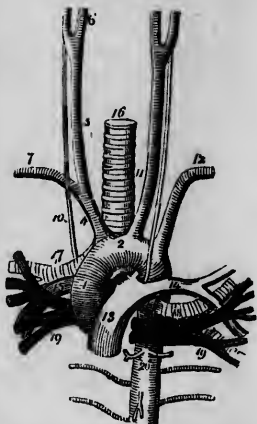


Fig. 221.—1. 2. 20. Aorta. 4. Innominata. 7. Right, 12. Left subclavian. 5. Right, 11. Left carotid. 6. Internal carotid. 16. 17. 18. Windpipe. 13. 14. 15. Pulmonary artery. 19. Pulmonary veins.

ending aorta; it soon forms half a circle, which is called the arch of the aorta; the next part is called the thoracic aorta; the next the abdominal aorta, which divides as it extends into the pelvis, and forms what are called the common iliac arteries. Branches from the aorta are seen almost as it leaves the heart; the two small coronary arteries extending to the heart itself, joined to the arch, the innominata, carotid, and subclavian arteries, are found. The peculiarities of these branches in relation to the aorta in different animals are curiously and strikingly exhibited by fig. 220, where 1 represents the right, and 4 the left subclavian arteries; 2 and 3 the carotids. The short one, forming 1 and 2 of the first figure, is the innominata. The relations of the arch to other parts is shown by fig. 221. On account of the form and relative positions of the ventricles, the pulmonary and systemic arteries commence very near to each other, and the branching of one and the arching of the other with the course of the pulmonary veins, renders the relative position of these parts rather difficult to understand or explain, except as it may be done by fig. 221.

The larger divisions of the arteries in the trunk are shown

Fig. 222.

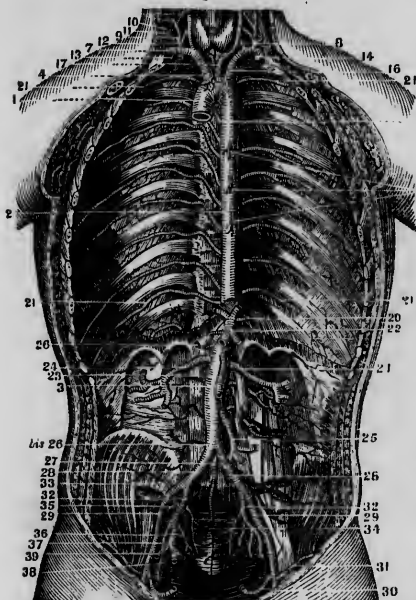


Fig. 222. 1, arch, 2, thoracic, 3, abdominal aorta; 4, arterial innominata; 5, right, 15, left carotid; 7, right, 16, left subclavian; 8, vertebral; 6, superior, 9, inferior thyroid; 10, anterior, 11, transverse cervical; 12, superior scapular; 13, superior intercostal; 14, internal mammary; 15, superior mediastinal; 18, intercostal; 19, oesophageal; 20 phrenic; 21, diaphragmatic; 22, celiac tripod; 23, superior, 25, inferior mesenteric; 24, emulgent; 26, fork of aorta; 27, middle, 34, lateral, sacral; 28, primitive, 29, external, 32, internal, iliacs; 31, circumflex; 33, ileo-lumbar; 35, gluteal; 36, vesical; 37, obturator; 38, ischiatic; 39, internal pudic arteries.

by figs. 222 and 223, representing a front and back view of the arteries.

The general arrangement of the arteries in the neck, is also shown by fig. 114, page 236. Those of the whole body, are shown by fig. 2, Plate 7, and fig. 1, Plate 5, and by fig. 35, page 112.

It is not important for the general student to know the situation of the arteries, of the extremities, except a few large ones which are exhibited in figs. 224, 225.

608. The use of the pulmonary artery, is to cause the

blood to flow from the heart to the capillaries composing in part the air-cells of the lungs.

609. The use of the systemic arteries, is to receive the blood from the left ventricle, and transmit it into all parts of the body.

610. The arteries are facilitated in the performance of their functions, by 1st, their elastic coat; 2d, their muscular substance; 3d, branching at acute angles; 4th, their protected situations; 5th, muscular action; 6th, rubbing the body.

Their elastic coat, prevents their curving at an angle, and also from closing, so that when the artery is cut across, it remains open, and its blood flows out freely, sometimes endangering life in a few moments.

Inf. To compress the bleeding artery, much force must be used, and applied also in a proper direction, so that the artery may be between the compress and the bone.

Fig. 223.

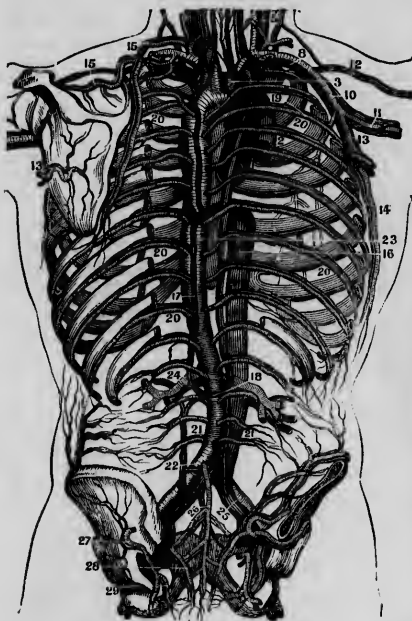


Fig. 223. 1, aorta; 2, vena cava; 3, arteria innominata; 4, carotid; 5, internal, 6, external jugular; 7 occipital, A. and V.; 8, subclavian, A. and V.; 9, vertebral, A. and V.; 10, axillary A. and V.; 11, humeral. A. and V.; 12, cephalic, V.; 13, subscapular, A. and V.; 16, azygos, V. 17, hemi-azygos, V.; 18, 19, openings of azygos into the venae cavae; 20, intercostal, A. and V.; 21, lumbar, A. and V.; 22, lumbar azygos; 23, aorta; 24, emulgent A. and V.; 25, iliac A. and V.; 26, middle sacral A. and V.; 27, gluteal A. and V.; 28, lateral sacral A. and V.; 29, internal pudic A. and V.

How much the muscular substance of the artery can assist in diminishing the flow of blood, is uncertain; it is probably connected with the sympathetic nervous system, and only through that, with the rest of the nervous system.

The difference between the angles of the veins and arteries is very conspicuous. The arteries are protected in two respects by one means, viz., from injuries, and the loss of heat, by being buried deeply on the protective, and warmest side of the bones and limbs.

Inf. a. If the extremities suffer from too low a temperature, the arteries should be buried still more deeply by clothing.

Inf. b. From the length of the arteries, it would be premised

that children and females must suffer much, thinly clad as they usually are in all kinds of weather.

Muscular exercise and rubbing the body, act upon the arterial circulation upon the same principle, though rubbing is also efficient, because it follows the blood along.

Capillaries.

611. *Capillaries* is the name given to those minute blood-vessels; which neither increase nor diminish by uniting or branching.

Fig. 224.

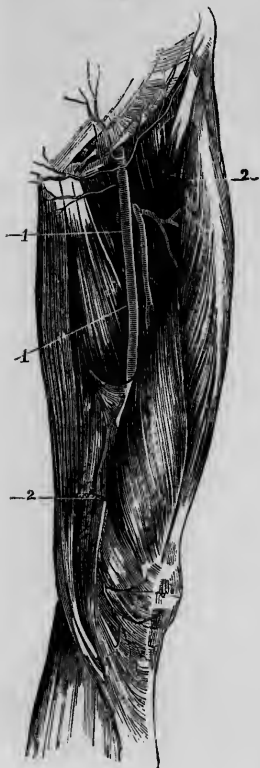


Fig. 225.



Fig. 224, represents—1, the large artery of the thigh; 2, 2, the cut ends of the sartorius or tailor's muscle. The situation of the femoral artery is between the inner edge of the sartorius muscle and the bone.

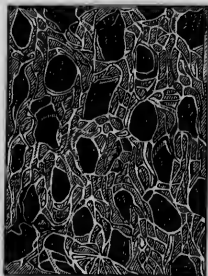
Fig. 225, represents the situation of the large artery of the arm, between the inner edge of the biceps muscle and the arm.

Their size differs somewhat in different parts of the body. They exhibit a network, the form and size of which differs according to the nature of the part examined, as seen by the accompanying figures representing capillaries from different parts of the body.

Fig. 226.

Fig. 227.

Fig. 228.



In many cases, the capillaries, so far as can be seen, are composed of merely a basement membrane. In others there is an appearance of a cellular layer with the basement, and in some, a few very fine fibres can be seen, while some suppose that muscular substance does in some form exist in the capillaries.

612. The *use of capillaries* is to receive the blood from the arteries, and bring it in close relation with the tissues.

Whether the capillaries have any action upon the blood, either to change its character, to cause it to pass into the tissues, or to cause substance to come from the tissues into the blood, is uncertain, but it is probable that they are mostly passive.

The capillaries are very sensitive to the action of mental influences, as is seen when the cheek is beautifully flushed by the action of refined emotions. They also become transiently enlarged in various states of health and exposure. On the other hand, the cheek is frequently blanched by the effects of fear, and when exposed to the action of low temperatures, reaction does not always take place, but the blood retreats from the capillaries. If reaction does take place, pallor will often be again produced, by the prolonged action of cold.

The rationale of these phenomena is not well understood.

613. The circulation of the blood through the capillaries depends upon the general health, the intellectual and dispositional character of the mind, the action of the tissues

where the capillaries exist, exercise of the muscles generally, and the rubbing of the system, and habit.

That proper habit, or use, improves every part, need not be argued. How it operates on the capillaries cannot be clearly shown, but experiment will prove that proper and frequent exposure of the skin to the cold, will cause the capacity of the capillaries, and the circulation in them, to be increased; the effect produced depending on the extent of surface exposed, and the length of time during which it is acted on, and the degree of cold which acts. The rule is that exposure is safe so long as reaction takes place, and comfort succeeds. If great debility exists, corresponding care must be taken, for then reaction may never occur.

Veins.

614. *Veins* is the distinguishing name of that kind of blood-vessels which manifest but little, if any elasticity, and increase, or diminish in size, as they unite or branch.

The veins are tubes essentially composed of serous membrane. In the fibrous layer or coat, there are a few elastic fibres, especially in some of the veins. It is also thought by some, that a trace of muscular tissue is manifested by most veins. It becomes quite conspicuous in the large veins which open into the auricles. The inner surface of the veins is continuous with that of the capillaries

Fig. 229.



and heart. Thus the inner surface of the hearts, arteries, capillaries, and veins, form a complete and uninterrupted circuit. Many of the veins are furnished with what are called valves—which, like those of the arteries, are folds of the inner portion of the vein, the surface of which is, of course, by so much longer than the outer part. Sometimes there is but one, sometimes there are two, opposite to each other. As the blood passes through them in its ordinary course, they are pressed against the side of the vein, but when the blood flows back it presses behind the valve, and against its upper surface, and thus causes its own backward course to be obstructed.

615. *Veins* are classed under three heads: the pulmonary, the systemic, and the portal.

The pulmonary veins commence by minute roots in the capil-

Fig. 229—*a*, valves in a vein; *b*, pouches above the valves.

laries of the air cells, and uniting, form two branches by the side of each division of the windpipe, and also extend as two branches from each lung to the left auricle. Thus the veins are twice as numerous as the arteries, and if a section of the windpipe be made, an artery and two veins will always be found by its side. The veins from the nutritious capillaries of the lungs open into the capillaries of the air cells. There are therefore two classes of pulmonary veins.

The systemic veins commence in the capillaries of all parts of the system, and uniting extend at last to the right auricle. In the extremities they are to be noticed as the superficial, and deep. The last follow the course of the arteries. The first are found near the

skin. The deep veins lead back the blood from parts where it has not been exposed to low temperatures. The superficial veins lead back the blood which has been cooled, and which should not too quickly be allowed to cool that which is flowing out, e. g., the large veins of the arm are situated on its inside, that the blood they contain may become warm without directly acting on that which is flowing out, and before it is poured into the chest and heart. The veins in the extremities are very plentifully furnished with valves. Some of the veins of the head are found in the dura mater which serves as their fibrous coat. Such veins

Fig. 230.

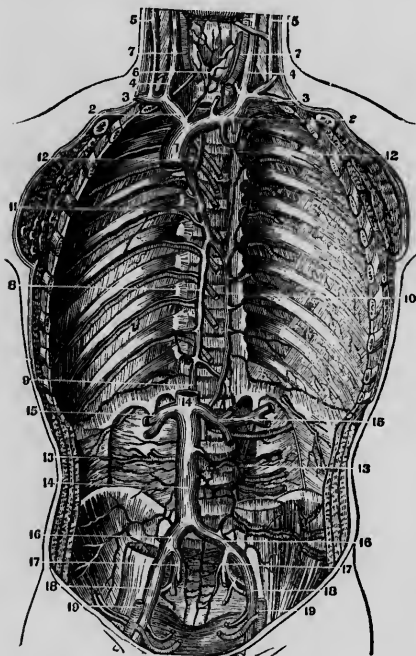
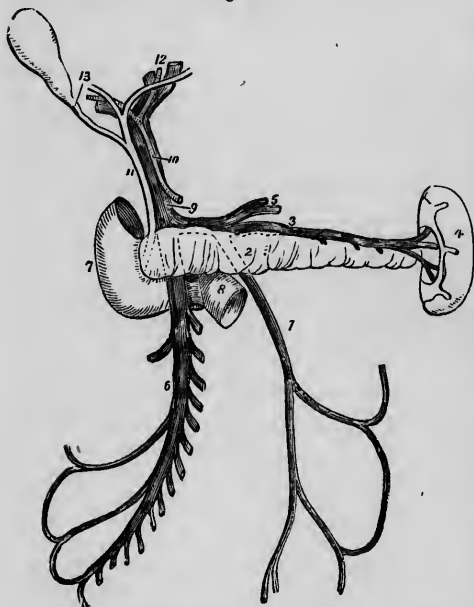


Fig. 230.—1, 14, venae cavae; 2, brachio-cephalic; 3, subclavian; 4 internal, 5, external jugular; 6, thyroid; 7, carotid; 8, 9, 11, azygos; 10, hemi-azygos; 12, superior intercostal; 13, lumbar; 15, emulgent; 16, iliac; 17, internal, 18, external iliac veins; 19, iliac arteries.

are called sinuses. All the veins from the upper part of the body, by uniting and converging, terminate in a single large one, as do those from the lower parts of the body. The former is called the vena cava descendens, the latter the vena cava ascendens; both terminate in the right auricle.

The *portal veins* are a class which lead from capillaries, and terminate in capillaries. They first unite, and then branch. The latter pulmonary class, mentioned above, belong to this order. In the kidneys a similar class may be found.

Fig. 231.



The most conspicuous group of portal veins, and those usually referred to when the term is used, take their rise in the capillaries of the stomach, second stomach, pancreas and spleen, when by uniting, they form the gastric, superior and inferior mesenteric, the pancreatic and splenic veins, which unite to form a single one called the vena porta; extending to the liver, it divides and subdivides, its branches terminating in the hepatic capillaries,

as rudely shown by the preceding and succeeding figures.

616. The *use of the veins* is to serve as drains, through which the blood of the capillaries can be removed and trans-

Fig. 231 represents the larger branches of the vena porta: 1, inferior mesenteric V.; 2, pancreas; 3, splenic V.; 4, spleen; 5, gastric V.; 6, superior mesenteric V.; 7, descending, 8, transverse, portions of duodenum; 9, vena porta; 10, hepatic artery; 11, Choledoch duct; 12, branches of vena porta, hepatic artery and duct, just within the surface of the liver; 13, gall bladder.

mitted to either the heart, or those capillaries where its presence is needed.

Fig. 232.



617. The *accomplishment of the functions of the veins*, is chiefly dependent on the action of the heart, arteries, and capillaries, of the muscles, rubbing the body, and loose clothing.

As the veins are flaccid, and many of the systemic veins situated directly beneath the surface, the circulation will not only be retarded by permanent pressure, but even altogether stopped.

Inf. Tight clothing must derange the action of all parts of the body, since it is absolutely dependent on the circulation of blood.

618. The *use of the entire circuit of the hearts, arteries, capillaries and veins*, is to keep the blood constantly moving through every part of the body; in larger quantities and more rapidly through some parts than others.

CHAPTER II.

The Blood.—Cause and Rapidity of its Circulation.

The characteristics and sources of the blood have already been considered, but as the welfare of all parts of the body depends on its circulation, it seems to be important to consider its causes and rapidity.

619. The forces which circulate the blood are to be found in the hearts, arteries, capillaries, the action of the tissues,

Fig. 232. An ideal representation of the vena porta 2; and its roots, 1, in the stomach, second stomach, spleen and pancreas; and its branches, 3, in the liver.

the arrangement of the veins, temperatures of the body, muscular exercise, and the expansion of the chest.

The hearts differ slightly in size and thickness, the right being the larger, and the left the thicker. Their capacity varies in different persons, and at different times in the same person, according to their degree of expansion. The quantity of blood thrown out will also depend something on their degree of contraction, which is much more complete at some times than others. Thus the quantity of blood thrown out by the heart will depend upon its natural size, degree of expansion, and contraction, and rapidity of action. Thus can the duties of the heart be increased or diminished as the case requires. The average size of the heart's cavities is two to three ounces, and about one half that quantity is thrown out at each pulsation. That the heart's action is dependent on the requirements of the system, is evident from the pulse being more frequent, the more active the muscles, and also when the emotions are excited.

Illus. When a person in health reclines, the pulse is about 70, when he sits, stands, walks, or runs, the pulse increases in due ratio.

I cannot perceive that the pulse is quickened by intense abstract, intellectual study; but the increase of circulation to the brain seems to take place at the expense of other parts, the action of which is not then required, as it often is when the emotions are active. Hence why students are apt to have cold extremities, and the head hot, and why it is best if possible to have the emotions active with the intellect; and as far as possible, also to have muscular exercise associated, or alternated with intellectual operations.

The arteries yield to receive the blood, and contract upon it with more or less power as the case may be; the contraction depending on the elasticity in the larger, and on it and muscular tissue in the smaller arteries. The action of the arteries therefore as well as the heart is dependent on the nervous system, and indirectly on the mind, the dispositional character of which remarkably modifies the circulation. In all the larger arteries, a throbbing of the blood, called the pulse, may be felt. It is mainly produced by the action of the heart, and in health takes place at the same time with the contraction of the ventricle. The qualities of the pulse are dependent also in part upon the arteries. By feeling the pulse therefore, the physician learns the condition of the heart and arteries, which would be of little consequence, except that he learns the condition of the nervous system and general health, which has caused any state of the heart and arteries. With his mind, therefore, an intelligent man looks back from one cause to another.

How much action the *capillaries* have upon their circulating contents is uncertain. All the *tissues* when active are decomposing and recomposing themselves, and exert very powerful attractions upon the blood or upon some of its components. At the same time it is not improbable that repulsive influences are exerted upon the useless substances; thus towards each part which is active, and requires much substance, much blood will be circulated; thus, while the heart pours out blood equally towards all parts, it will be solicited to those particular parts where it is most required. When therefore one part is active, another should not be, except when they have been designed for mutual activity, when the action of one assists that of the other. This is a very important truth.

The *arrangement of the veins* is such, that most of them open into each other at right angles, and it is a principle of hydrostatics, that if a fluid be flowing from the smaller toward the larger extremity of a tube, it will draw into itself any fluid that can flow through a tube opening at right angles into the first.

Temperatures of parts modify the circulation upon several principles. One effect of cold and heat is to contract and expand most objects, and continuously applied, they will always have those effects on the animal system. But the powers of life antagonize the natural action of many things. When the application of any thing cold removes heat, the part is in danger, and at the same time that through the nerves a sensation of cold is produced, the involuntary nervous influences are then exerted, so as to produce a rush of blood to the exposed part. This is called reaction. The length of time during which the tendency of the cold can be resisted, will depend upon the amount of surface exposed, the degree of cold, and the health of the person. In some persons reaction instantly occurs, in others only after a little time, and in some who are very feeble, so very slowly, that it is not termed reaction.

Again, cold applied to any part till it reduces the circulation, causes the accumulation, or increased circulation of blood in other parts, which is often more dangerous than the first evil. On the other hand, warm applications, by increasing the quantity or circulation of blood in one part, diminish it in another; a very important principle.

Muscular exercise and rubbing, increases the activity of the circulation, not only in the muscles, but through all parts, by intermitted pressure upon the vessels, and by the influence exerted upon and through the nervous system.

The *expansion of the chest* draws the blood toward the heart.

The *position* of the various parts of the body exerts an important influence on the circulation through them. In the extremi-

ties valves are found ; but yet continuous pressure of muscles, as in standing a long time, interrupts the flow, distends the veins, and the valves become inefficient. External pressure upon the whole extremity counterbalances the evil to a degree. In the head valves do not exist. It should not long be held below the level of the chest. This should be kept in mind when children are washed and dressed. When sleeping, the head should be slightly elevated.

The *rapidity of the circulation* varies with the action of the forces which control it. Under any circumstances the movements of the blood will astonish any one who first computes them.

CHAPTER III.

Lymphatic System.

620. *Lymphatic system*, is the name given to a great number of vessels distinguished by their beaded appearance, and the numerous glands with which they are associated, and which form part of the system.

Fig. 233.

In the bones, cartilages, dense fibrous tissues, brain, spinal cord, and eye, they have not yet been detected. The vessels extend in slightly converging, but nearly parallel lines, toward the centres of the body. It is by some thought that they frequently open into veins, but this is not probably the case in man, where they open into the veins only at the angles formed in the neck, by the jugular and subclavian veins. They frequently form with each other anastomoses, as seen by fig. 90, at which places the cells of

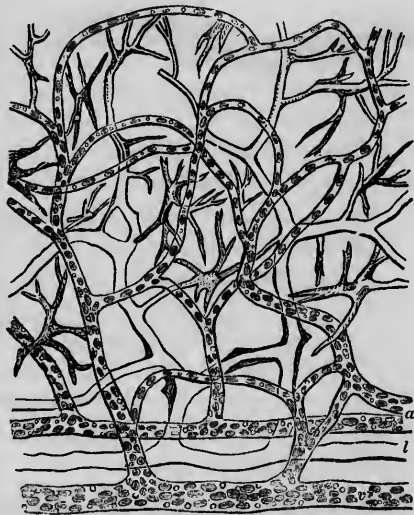
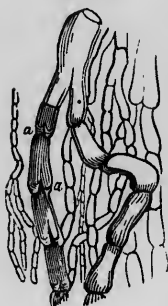


Fig. 233 represents a view of the capillary and lymphatic network, a thousand.
B. 3.—17

Fig. 234.



their inner surface become developed and active, (fig. 89,) an additional supply of blood-vessels is furnished to them externally, and the whole interwoven with and covered by fibrous tissue, by which a gland is produced from which fewer vessels extend than entered, till at last, only two pour the contents of the whole system into the veins. Some think that in the glands the blood-vessels and lymphatics communicate, or that the capillaries absorb the lymph.

621. The *lymphatic system* is divided into the systemic lymphatics, and the lacteals (or lacteal lymphatics).

A few of the millions of vessels and glands are represented by Plate 4. Most are too minute to be seen with the naked eye. They are composed of a very delicate serous membrane, the whole thickness of which is folded inward at quite regular intervals, forming valves as seen by fig. 235, and a beaded appearance externally.

Fig. 235.



They form a network in the parts in which they commence, where the vessels are so numerous and so minute, that they cannot be seen by the naked eye, and when magnified, present an almost incredible appearance.

622. The *lacteal system* is distinguished by commencing in the papillæ of the second stomach, as hereafter shown.

623. The *use* of the *lacteals* is to absorb certain portions of the food, and prepare them for the blood.

The systemic lymphatics contain lymph, but their use is yet an enigma in physiology—of which there are yet a sufficient number to stimulate the ambition of any student, who wishes to enroll himself among the few immortal learned whose names adorn the pages of scientific history.

624. The action of the lymphatics will be facilitated by proper temperatures, muscular exercise, rubbing the system, and loose clothing.

times magnified; *a*, artery; *v*, vein; in which and the connecting capillaries, the blood cells, glands, or corpuscles are seen; *l*, lymphatics.

Fig. 234, lymphatic vessels.

CHAPTER IV.

Closed or Sanguific Glands.

625. The name of closed or shut glands, are given to four different parts of the body, which have no communications except with the blood-vessels. They are the spleen, the supra renal capsules, the thymus and the thyroid glands.

They are also called vascular glands, on account of the numerous blood-vessels, of which they are in part composed, and sanguific glands on account of their supposed utility in forming the blood.

The *spleen* is about the size of a kidney, it is quite smooth on its external surface. It is composed of fibrous tissue, in the meshes of which a great number of cells are found, and a multitude of blood-vessels. It is situated beneath the diaphragm, to the left of the stomach, against which it rests. Its use is to alter in some way, the blood which flows through it. Its particular effect has not been ascertained.

The *renal capsules* are small parts attached to the upper portion of the kidneys. They are composed of fibres, cells and blood-vessels, lymphatics and nerves. Their particular use is not known.

The *thymus gland* is situated just behind the upper part of the sternum. In early life it is much larger than at mature years. It is composed of fibrous tissue, cells, blood-vessels, lymphatics, and nerves. Its particular use is not known.

The *thyroid gland* is situated on the front of the trachea just below the larynx. It has something the appearance of a saddle, and is spoken of as composed of three lobes, the two lateral and middle. It is composed of fibrous tissue, cells, blood-vessels, nerves and lymphatics. Its particular use is not known, but its importance seems to be considerable. It is frequently enlarged, producing a "swelled neck," or case of "goitre," or "bronchocele." This enlargement seems to have some connection with the use of hard water. I have seen but one case where the individual had always used soft water.

REVIEW.

A view of the living circulatory apparatus exhibits the two hearts side by side, throbbing actively at the rate of 75 to 80 times

per minute, and pouring out from 3 to 10 tuns of blood per hour, the pulmonary artery pulsates with its contents which are driven to the vitalizing air of the pulmonary aircells. The systemic heart receives the oxygenated blood from the lungs, and pours it out in life-giving streams through the systemic arteries, to fertilize all parts of the republic, of which the heart is the mercantile capital. The billions of capillaries in all parts of the body are seen to be flushed with the nutritious currents which come gushing into the more active organs, while the blood, with intermitting flow, spreads more slowly through parts which less need its components. But quietly or slowly, onward it is driven; here, leaving elements which are required for nourishment, and there, receiving those which have lived, acted, and died; all the while its own character is thus changed, and, also, by the decomposing and recompounding of its own components with each other as it moves along. As the swift river takes its rise from the brooks, the rills, the springs, and the uniting water drops, so are the systemic veins seen to gather the blood, unfit at present for further use where it is, from the almost invisible capillaries in all parts of the body, and at last, by the superior and inferior venæ cavæ pour a swift current into the pulmonary heart, which expanding to receive it, contracts to cause it again to be spread out to the air in the capillaries of the lungs. In the mean time the lymph and chyle are drawn into the circulation, and swallowed up by the blood of which they become a part. Thus round and round circulates the blood, that from one part being mingled with that from another. Some of its components fall into the current poured upward to the head, if not needed there round they come, down the jugular vein into the right heart, out through the lungs, and if not there removed, round to the systemic heart, from whence they may again be poured upward to the head, but more probably passed with the current leading to some other part; if not there needed or removed, again they circulate through the lungs, and perhaps for a thousand times, till at last they pass through some part which needs or eliminates them. In several different parts of the divided currents of the blood, useless, and when accumulated, poisonous substance is removed from it—while, in several other parts, are situated organs for perfecting the character of the blood.

Whenever a muscle is contracted, an impulse is given to the whole circulation, so also when any part is rubbed; cold applied continuously, checks the circulation in the part affected, and causes an injurious circulation, or congestion, of blood in other parts. Thus a cold skin is attended with sanguineous accumulation in the internal organs. All improper mental action manifests itself at once in the circulation, while all irregularities of the circulation injuriously affect the mind. Any compression checks the circulation, and

reduces the temperature of the body. On the other hand, wholesome food, a proper quantity of it, and a good digestion, a proper supply of pure water, pure cool air in suitable quantity, healthful exercise, thorough rubbing, comfortable temperatures and the beneficial action of a regulated intellect and disposition, give a healthful and lively circulation to every part, which exhibits corresponding efficiency in all its functions.

DIVISION II.

ANALYSIS.—*Character of Respiratory Apparatus—Composed of Air-passages, Lungs, Chest, and Respiratory Muscles—Structure and particular uses of each—Mode of respiration—Air—Its composition, temperature, quantity respired, and effects—The respiratory apparatus as organs of speech.*

Respiratory Apparatus.

626. The *respiratory apparatus* essentially consists of an immense number of very minute pouches, with delicate tubes terminating in groups of them, and an apparatus adapted to cause the air to pass into and out of them. It may, therefore, be considered under the heads of—1st. The air passages and lungs; 2d. The chest, respiratory muscles, and respiration; 3d. The air; 4th. Its relations as an apparatus of speech. The use of the apparatus is, to expose a large quantity of blood, in very thin portions, to a great surface of air, and thus cause the rapid action of the blood and air upon each other; incidentally, it serves the purpose of speech.

In some animals, the skin serves the purpose of lungs, as well as for absorbing food and drink, and excreting various substances. In some a single pouch exists, which serves the common purpose of a stomach and lungs. In the higher orders the office of the lungs is assigned to distinct organs, but *two* offices yet remain to them—absorption from the air and excretion into it. They are both very simple, and only require that the air and blood should be exposed to each other. The extent of surface requisite for doing this effectually will depend on the animal, and to a great degree upon its

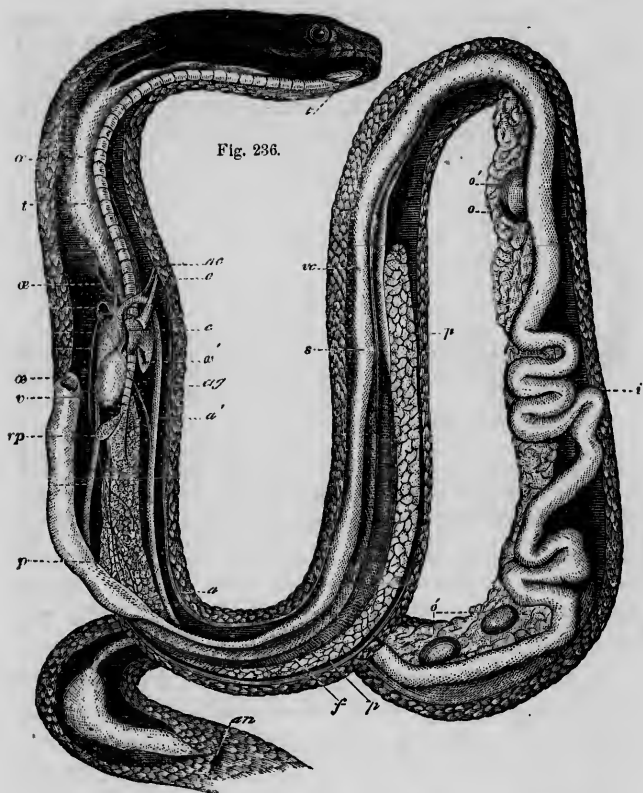
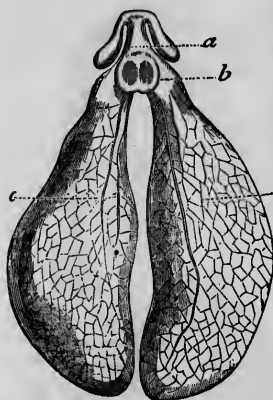


Fig. 239.



muscular activity. In some a simple pouch of no great size, composed of a double membrane as in the serpent, is all that is necessary. In the frog and turtle a slightly complicate arrangement exists, the inner or mucous membrane being folded inwards, so that the inside of the lung presents a honey-comb appearance like one of the stomachs of a cow, as seen in tripe—see fig. 239, where *a* represents the jaw of the frog; *b*, the opening into *c*, the lungs—the divisions being seen through the external serous membrane.

Exp.—Open carefully a turtle or frog, remove the lungs, and inflate them, let them dry, and cut them open.

In the higher animals the problem is, to expose the air to a greater proportional surface, in a smaller proportional cubical space. The outer surface of the lungs need not be very different, merely a serous pouch, but within will be needed a very complicate arrangement, to present a very delicate mucous membrane, which is the essential part, to the air. They are therefore composed of several parts in addition to the simple membrane of the lower animals. With these general principles in mind, we may pass to a consideration of the special structure of the air passages and lungs.

CHAPTER I.

Lungs and Air Passages.

627. The *air passages* include, 1st, the nose; 2d, the pharynx; 3d, the larynx; 4th, the trachea; 5th, the bronchi; 6th, the air cells.

The nose is usually reckoned as the natural air passage to the lungs, as its membrane in structure, diseases and causes of them,

Fig. 236 represents the internal organs of the coluber; *t*, trachea; *rp*, rudimentary lung; *p*, lung; *œ*, œsophagus; *s*, stomach; *f*, liver; *i*, intestine; *v*, ventricle; *ra*, right, *la*, left auricle; *pv*, pulmonary, *sv*, systemic vein; *a*, aorta; *pa*, pulmonary artery.

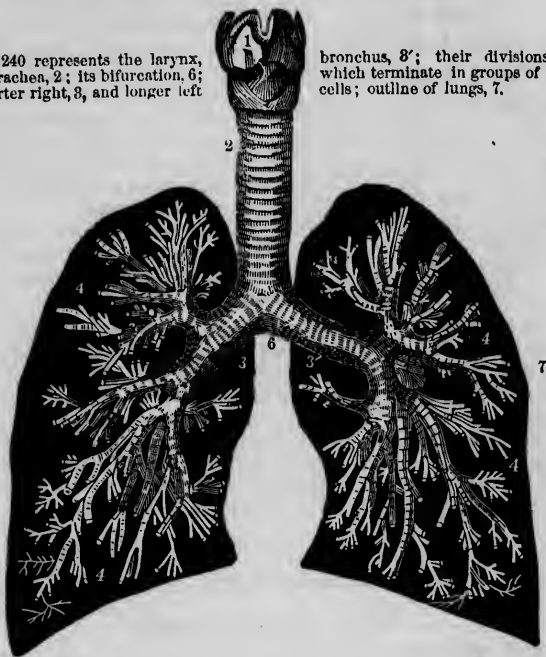
Fig. 237—*a*, trachea; *b*, undeveloped lung; *c*, lung, a mere tubular sac.

Fig. 238—*a*, trachea; *b*, slightly developed lung; *c*, lung with partial divisions.

strikingly corresponds to the mucous membrane of the lungs. The narrowness of the nasal passages prepare, if necessary, the cold air to enter the sensitive parts below. The pharynx is common to the air and digestive passages, and its membrane partakes of the nature and diseases of both those parts.

Fig. 240 represents the larynx, 1; the trachea, 2; its bifurcation, 6; the shorter right, 3, and longer left

bronchus, 8; their divisions, 4, which terminate in groups of air-cells; outline of lungs, 7.



The larynx is chiefly for the purposes of speech, its epiglottis, however, serves to obstruct the passage of obnoxious substances into the lungs. If an opening into the air passages be made below it, breathing takes place perfectly well. The trachea serves merely to communicate between the larynx and the lungs, and for purposes of breathing, and except for convenience and the purposes of speech, might equally as well have opened directly on the surface of the chest, where the nose would then have been placed, as in some animals is the case. The bronchi are the names given to the divisions of the windpipe between the trachea and air cells. They serve merely to lead the air into and from the cells.

The air or pulmonary cells, or vesicles, are not, properly speaking, air passages, but terminations of them, into which the air is drawn, and from which it is expelled.

628. The *lungs* are composed of, 1st, the mucous membrane; 2d, cartilages; 3d, yellow ligament; 4th, muscular tissue; 5th, areolar tissue; 6th, serous membrane (pleura); 7th, pulmonary blood-vessels (3 kinds); 8th, nerves; 9th, systemic blood-vessels (3 kinds); 10th, lymphatics. All of these parts may be grouped as follows: the first four form air passages and cells; the first eight prepare the lungs for action; the last two keep them in repair.

The *mucous membrane* forms the inner portion of the bronchial tubes, and also forms the walls of the air cells. It becomes more delicate, the lower it is traced, and in the cells its three layers of epithelium, basement, and fibrous membranes cannot always be made out; where the epithelium is distinct, its cells are furnished with cilia.

The *cartilages* of the lungs exist in the form of four fifths of rings in the larger tubes, but in the smaller ones several small pieces represent the place of the single one above. They are of use in keeping the passages distended, and exist not upon the sides of the cells.

The *yellow ligament* is composed of yellow fibres, and completes the tubes which the cartilages only partially form. The fibres of this part blend with those of the fibrous membrane of the mucous membrane.

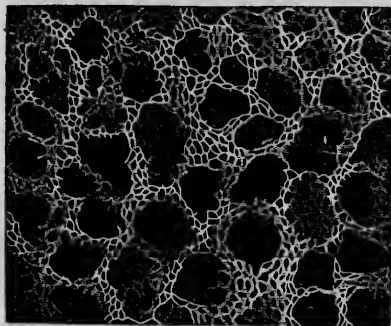
The *muscular tissue* in the lungs is of the unstriated kind, and exists in the midst of the fibrous portion of the air passages.

Thus are formed, an almost infinite number of divisions of air tubes, and a very much greater number of air cells, by which in a very small space a wonderful extent of surface is presented to the action of the inspired air.

The *areolar tissue* of the lungs, is composed partly of white and partly of yellow fibres, which bind together somewhat loosely the cells and tubes, and form meshes for the situation and support of the very numerous vessels and nerves which compose a part of the lungs.

The *pulmonary blood-vessels* include arteries and veins which are situated by the side of the air tubes, and the capillaries, which in part compose the mucous membrane of the sides of the air cells. These are so numerous, that although the capillary is finer than a hair, it is sometimes acted upon on one side by the air of one cell, and on the other by the air in another, (see fig. 241), which

Fig 241.



represents some of the capillaries about a few of the air cells. Thus an immense surface of blood is exposed to an equally large surface of air in a small space and very speedily.

The *nerves of the lungs* are derived from two sources, the 9th pair, and the sympathetic system. By the first it is thought that sensations are caused, and by the second, organic influences exerted.

The serous membrane of the lung, called, also, the pleura, is found at the surface of the lung, covering in its other parts completely, except where the bronchi and blood-vessels enter and leave the lungs. Its fibrous membrane blends with the areolar tissue of the lung, while its cellular or epithelial layer forms the surface of the lung, and keeps itself continually moistened with a serous fluid it pours out. It is this membrane which is inflamed in case of pleurisy or pleuritis.

The *systemic blood-vessels of the lungs* include the bronchial arteries, the portal veins, and the nutritious capillaries. The distinction between the pulmonary and bronchial arteries is, 1st, that one leads blood from the right, the other from the left heart; one transmits dark blood to be acted on and improved, the other transmits light red blood which has been acted on by the air; one leads to the air cells only, the other opens into the capillaries of the substance and the surface membranes of the lungs. The portal veins are short, and lead blood from the nutritious capillaries to those of the air cells. Though, therefore, two kinds of arteries lead blood into the lungs, only one kind of veins lead it out from them.

The lymphatics of the lungs correspond to those in other parts.

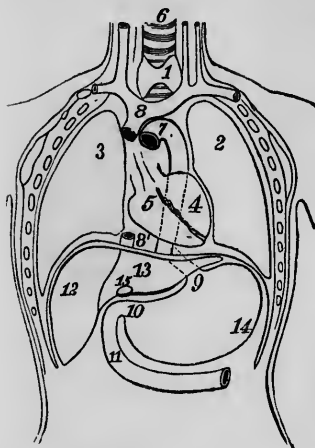
629. The *bronchus* of the right side has three grand divisions, which are the basis of the three lobes of the right lung—which are distinguishable externally (See fig. 216). The left bronchus has but two grand divisions, and the left lung but two lobes.

Smaller divisions of the grand branches of the bronchi cause

lobules to be formed, which produce a slightly uneven surface of the lung.

630. The *lungs occupy* when distended the entire cavities of each side of the chest; the heart being located between them, as shown by fig. 242.

Fig. 242.



The lungs are convex where they touch the sides of the chest, conical above, where they rise a little above the first rib, concave below, where their surface conforms to the arched form of the diaphragm, and as it is deeper behind so is the lung. On the inner surface the lungs are very concave, partially receiving the heart, as seen by fig. 244.

631. The *capacity of the lungs* always conforms to the size of the chest.

The size of the lungs is chiefly dependent on the air which they contain. If therefore the wind-pipe be not closed, the lungs cannot be compressed, for the mobile air would be expelled, and leave

room for the substance of the lung. A consideration of the chest is next important.

CHAPTER II.

The Chest and Respiration.

632. The chest and thorax, are names given to that part of the body which is above the diaphragm. It exhibits walls and cavities. The walls are composed of a framework, serous membranes, and muscles. There are three cavities, one on each side filled with the distended lungs, and a central one occupied by the hearts. In addition, there are the anterior and posterior mediastinum.

The *framework* of the chest has been particularly described heretofore, and requires no further mention here.

There are two serous membranes which assist in forming the chest, one on each side. They are called the right and left costal pleuræ. Each one lines the ribs of its own side, closes the top and bottom of the framework, and passing across from the spinal column to the sternum, thus forming each side of the chest into an air-tight box. At the roots of the lungs it becomes continuous with the pleura covering them. All of these things are represented by the adjoining partly ideal figures.

Fig. 243.

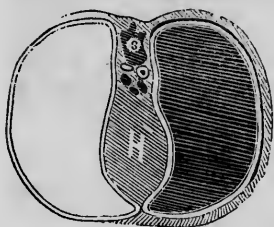


Fig. 244.

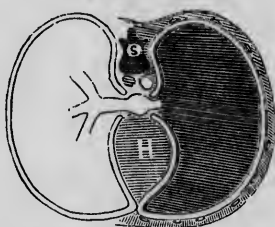


Fig. 245.

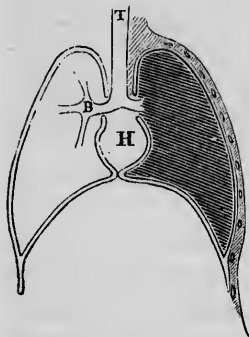


Fig. 243 represents a transverse section of the chest, below the roots of the lungs. (See Fig. 216.) On one side the walls of the chest are seen, on the other the pleura only. It is here seen to completely surround the lungs, and completely line the chest.

Fig. 244 is the same as the previous one, except that the section is made at the level of the roots of the lungs, and the pleura forming their surface, and that which forms the inner surface of the chest, are observed to be continuous.

Fig. 245 represents a perpendicular section of the chest on one side, and the lungs, and pleura only on the other. The section has been made through the windpipe and roots of the lungs.

This arrangement of the pleura is sometimes described by saying, that the pleura is reflected from the lungs onto the ribs, or from the ribs onto the lungs. The fibrous membrane of

the pleura is blended with the fibres of the periosteum of the ribs, and the areolar tissue of the muscles—while its epithelial surface is lubricated with serum, and therefore will not become adherent to the lungs, which are gently in contact with it. Behind and in front of the heart, the pleura from each side approach each other, and adhere together, forming in one sense a single partition.

Between these points the two pleuræ are separated by the heart, the space which it occupies being called the middle mediastinum. Between where the pleuræ meet in front and the breast bone, a triangular space called the anterior mediastinum is formed, in the upper part of which the thymus gland is situated. Between the meeting of the pleuræ and the spinal column, another triangular space called the posterior mediastinum is found, in which the wind-pipe, œsophagus, and large vessels are situated.

The muscles of respiration have been previously described.

633. *Respiration* is the name given to the double process of inspiration and expiration; the object of it is the constant change of the air in the lungs.

634. *Four different kinds of forces* are active in the processes of respiration; two are exhibited by the muscles and cartilages, one by the elasticity of the lung, and one by the air.

The muscles of respiration elevate and depress the chest, and diaphragm, and thus increase and diminish the size of the thoracic cavities. In this they are assisted by the cartilages which tend to keep the chest at a medium size, so that when the muscles expand or diminish it beyond this point, the cartilages tend to restore it.

The elasticity of the lungs, and perhaps the muscular power in addition is considerable. It must always be less than the force of the air. It must chiefly depend on the yellow fibrous tissue of the lung, since it is preserved by alcohol. Its action will be seen if a person attempts to inflate a pair of lungs or lights of an animal.

It resists the expanding force, and the instant it is removed restores the lungs to their former small size.

The natural weight of the air varies under different circumstances, but averages at the surface of the earth 15 pounds to the square inch.

If the lungs are removed from the chest, the pressure of the air will be equally exerted upon the outside and inside of them, and the elasticity of the lungs will keep them empty, which state is called collapsed, and the lungs will appear very small. When the lungs are in the chest, it being air tight, prevents the air from pressing on the outer surface of the lung, and the internal pressure of the air having nothing to balance it, overcomes the elasticity of the lungs, and expands them till their outer surface is in contact with the pleuræ. This contact is very gentle, for the elasticity of the lung tends constantly to collapse them, and therefore tends to produce a vacuum between the lungs and chest. The internal pressure

of the air through its passages, therefore, is the cause not only of expanding the lungs, but of keeping them in their places, so that they cannot change their positions, except as the capacity or form of the chest is changed; while on the other hand, the elasticity of the lung opposed by the elastic air is the most delicate spring conceivable, and ever prevents the lungs from pressing or being pressed upon injuriously, except when the windpipe is closed, and seldom then can they be injured.

As soon as the lungs touch the internal surface of the chest, the action of the air upon the chest balances the internal action. When the chest is enlarged, the external pressure is removed again, and instantly the internal action expands the lungs accordingly. In other words, enlarging the chest tends to produce a vacuum between the chest and lungs, and the air presses out the lungs to prevent it. When the chest is diminished, the external pressure of the air balances the internal, and the elasticity of the lungs contracts them accordingly and instantly. The chest cannot therefore compress the lungs as long as the windpipe is open, and if it is desirable to emit air with force, the windpipe must be closed, and then the chest diminished, and the contained air compressed; as soon as the windpipe is opened, the elasticity of the air and lungs will cause it to gush out as in speaking, singing, &c.

635. In *inspiration*, the chest is expanded, and the external pressure of the air removed, and then the internal pressure of the air expands the lungs.

636. In *expiration*, the external pressure of the air is allowed to act, and the elasticity of the lungs expels the air.

The first causes of inspiration and expiration, are, the removing and restoring of the external pressure of the air, but the direct causes are the internal action of the air, and the elasticity of the lungs.

Another action of the air should be noticed. If it be, as usual, cooler than the lungs, it expands as it is warmed in them, and expands them of course, and is brought more forcibly in contact with their inner surface, and acts more perfectly and quickly on the blood.

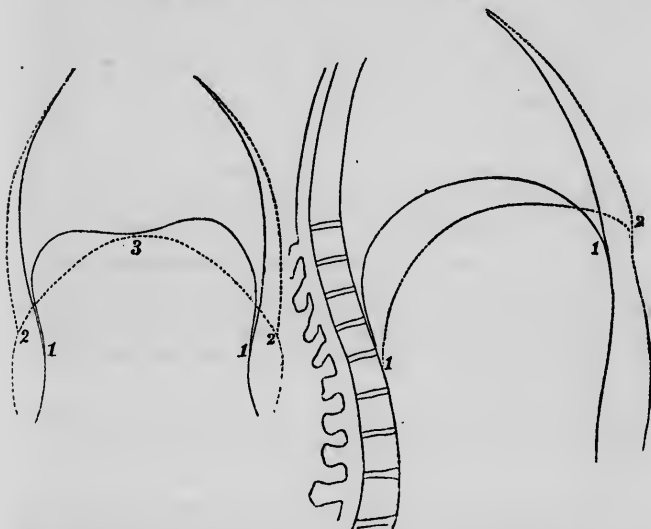
The effect of respiration upon the organs of the abdomen, and their action upon it, should also be considered. The following figures show by their continuous lines, the state of the diaphragm, 1. 1. and the walls of the chest and abdomen, after expiration, while the dotted lines show the same parts after inspiration.

When the muscular parts of the diaphragm contract, they press downward all the organs below, and thus distend the walls of the sides and front part of the abdomen. But the arches of the dia-

phragm are so constructed and situated, that they tend to press the stomach and liver towards a point near the centre of the front walls of the abdomen, which therefore is chiefly distended. This is directly beneath the centre of the strong and long recti muscles,

Fig. 246.

Fig. 247.



which must be correspondingly relaxed and extended. When therefore they contract, they not only depress the chest, but as the oblique and transverse muscles contract at the same time, will react through the abdominal organs against the diaphragm and press up its relaxed arches, while at the same time the elasticity of the lungs tends to draw them up.

637. *Vigorous or healthy respiration* depends upon the free movements of the chest and abdomen, upon the healthy and extensive action of the respiratory muscles, upon the health and elasticity of the cartilages, upon the elasticity and muscular force of the lungs, and upon the qualities of the air.

638. Nothing can be more evident than that *all constrict-*

tion of the trunk by *clothing*, or any thing else, and *every thing* which *interferes* with its *flexibility*, and perfect *freedom of motion* in every direction, *impedes the process of respiration*, and entails upon the system that *long train of evils*, which arise from the inefficient action of the air upon the blood, and which show themselves in a *bad complexion*, *dull eye*, *languor of expression* and *every muscular action*; *want of elastic spirits*, *intellectual incapability*, and an *irritable disposition*.

639. *Proper exercise*, is an important means of producing vigor of the muscles, and a healthy elastic state of the cartilages, and elastic tissues concerned in breathing.

Going up hill and down, riding on horseback, bowling, reading aloud, singing, and every exercise which increases the action of the breathing apparatus, at the same time that it causes a variety of positions to be taken, especially by the trunk, will, if gradually entered upon, and regularly increased to a proper degree, prove highly advantageous.

640. The *influence of the mind* upon the respiratory apparatus is one of the most conspicuous and important that can act.

This will be proved, by the effect of almost any emotion. While therefore on the one hand, the respiratory apparatus should be exercised in pure cool air for the benefit of the mind, the mind should be cultivated, and the favorable influence of pleasant emotions should be not merely allowed, but caused to exert their desirable effects upon the essential functions of respiration.

CHAPTER III.

The Air.

641. *Air* is the name given to any portion of the atmosphere. It is a gaseous mixture, composed chiefly of nitrogen, in which are dissolved about one-fourth or fifth its own quantity of oxygen, a very small quantity of carbonic acid,

a very variable quantity of water, and every kind of exhalation.

The proportion of *nitrogen* to the whole bulk of air inhaled, is similar to that of the air exhaled. The proportion of the *oxygen* is always less in exhaled than in inhaled air. The variation depends upon the proportion of oxygen in the air inhaled, its temperature, and the action of the lungs. The less the proportion of oxygen in the inspired air, the less will be the amount removed.

Inf. If a person reinspire air, there will not be as much effect produced by it the second as the first time.

The proportion of *carbonic acid* is always greater in the expired air. The amount of it depends upon the quantity of oxygen inspired, its temperature, the state of the blood and the action of the lungs.

Inf. When air is reinspired, the quantity of carbonic acid expired is less the second than the first time.

Water exists in the air in the form of vapor. It is probable that the air expired is always saturated with it, while the quantity inspired is very variable. If saturated, the inspired air is not probably in itself unhealthy. When, on the other hand, the inspired air is too dry, it produces ill health, since it absorbs too much water from the parts with which it comes in contact. The *exhalations* which sometimes seem to saturate the air are of every conceivable kind. If the portion of air in which a person is inclosed is small, it is very soon filled with the exhalations of the lungs and skin. To think of taking these back with the inspired air into the lungs, would be revolting to every person of refinement. The heat of the expired air and of the evaporating excretions of the skin will carry off all unhealthy exhalations, if a well ventilated apartment will allow them to escape. What must be the state of that air where a score, a hundred, or a thousand people are confined in a room, car or church, barely large enough to contain them. If refined taste would prevent a person from eating after another, how much more ought it to prevent him from drawing into the inmost depths of his delicate lungs, the air of an illy ventilated apartment loaded with the most offensive and unhealthy exhalations.

642. The *temperature* of the air has a very notable influence upon its effects.

When the temperature of the inspired air is lower than that of the body, it expands; if it be higher, it contracts: in the first case,

expanding the lungs more perfectly and acting upon the blood more efficiently; in the second case, producing but a slight comparative effect upon the blood, while the effect it receives is equally feeble. The expired, or dead, is usually higher in temperature than the surrounding air, and rising carries with itself the exhalations of the lungs, which should never be inspired. Hence after expiration, a moment's rest of the respiratory apparatus may be noticed, both because then the blood and air in the lungs are acting most rapidly upon each other, and that time may be allowed for the perfect escape of all the expired air.

If the air be very cold it will sometimes require more heat to warm it than it is the means of producing. This is the case with infants, old people, and some invalids. It should then be warmed before it is inhaled.

643. The *quantity* of air respired in a given time, depends upon the temperature of the air, the capacity of the chest, the extent of its motions and their frequency.

In the summer there cannot be as much air inhaled as in the winter, neither is there as much needed where but little heat is to be produced. The natural capacities of chests differ, but all are naturally constituted for mobility, upon which, in the second place, the quantity of air respired depends. The form of the chest is of little importance, provided it is extensively movable. The frequency of the respiratory movements differs in different persons, and in the same person at different times.

644. The *mode of action* of the *air* in the lungs and upon the blood, is not yet well understood. Oxygen disappears and carbonic acid appears during the process of respiration, is all that can at present be said with perfect certainty.

It is probable that an interchange of gases between the air and blood takes place, as it does every where, when different gases are presented to each other. Oxygen also is probably attracted by some of the components of the blood, but by which ones it is as yet impossible to say. Some of the oxygen may unite with carbon in the lungs, and be expelled with the expired air as a part of carbonic acid.

645. The *particular effect* of the *air* cannot be exhibited, yet in a thousand ways it can be demonstrated, that the

oxygen it contains is of vital importance to the construction and action of every part of the body, and in sustaining its temperature.

Inf. Nothing can be of more importance than ventilation, both day and night.

No harm can possibly follow, while the beautiful tint of the complexion, which the poet compares to the "lily dipt in wine," the brightly beaming eye, the elastic muscles, the sparkling wit, the vigorous intellect, and amiable harvest-producing disposition, can only be found in perfection when the whole atmosphere is the unlimited fountain from which a person draws his breath. Let then the bedroom, the workshop, the parlor, the office, the school-room, the hall of justice, the church, the concert room, and whatever places are occupied by men, or breathing animals, be thoroughly ventilated. It is never a saving to use less fuel and sacrifice health and beauty. Let not any currents of air sweep across the skin, and there is never any danger of "taking cold," by breathing the air fresh from out doors, no matter how cold (with the exceptions before made), or how damp it may be. Ventilation can never be too thorough. There is constant danger it will be inefficient.

CHAPTER IV.

Speech.

646. The *organs of speech* may be arranged in three groups: the bellows apparatus; the vocal organs; and the organs of articulation.

647. The *bellows* includes the lungs and trachea, the chest, and respiratory muscles.

The lungs affect the voice, by their capacity, elasticity, and perhaps by their muscular structure. By their capacity, they affect the resonance of the voice, and the fulness and duration of its tone. Hence the voice of females is almost always suppressed, and even the voice of Jenny Lind would be improved a hundred-fold, if she should leave the chest free, and allow the lungs perfect expansion.

The chest affects the voice by its constitution, its capacity, and its mobility. The elasticity of the various parts of the chest is one of its most important properties, and should be preserved and

increased with the greatest care. The capacity and mobility of the chest, is affected by the organs of the abdomen, and the clothing of the entire trunk. Hence the voice is dependent upon the same things.

The respiratory muscles affect the voice by enlarging and diminishing the capacity of the chest. The expiratory muscles are most important, and the perfection of their action depends upon the suddenness and delicacy with which their contraction can be controlled, and the length of time during which it can be continued.

648. The use of the *bellows* is to receive a large volume of air, and exert upon it an elastic pressure, which varies in degree, according to the impetus with which air should be expelled. Exercise, good health, and favorable mental influences are the requirements for the perfection of this apparatus in regard to speech.

Whether the influence of the mind is exerted directly upon the lungs, or chiefly upon the respiratory muscles, is uncertain; but one of the most important things to be kept in mind is, that the ease with which speaking or reading is accomplished, depends upon the emotions. Fervent interest in what a person is saying makes the exercise of speaking a pleasure, rather than a task, while there is no labor more exhausting than to speak for any length of time when the heart is not in the work.

649. *Vocal organs* is the name usually, though not with propriety, given to the various parts of the larynx. It is composed of cartilages, ligaments, muscles, and mucous membrane.

The *cartilages* of the larynx have already been described. Its *ligaments* bind the cartilages together, and two of them, covered with the mucous membrane, form what are called the vocal ligaments or cords. They stretch from the front to the back of the inside of the larynx, side by side; the space between them and the sides of the larynx is closed by the mucous membrane. The space between them is something like a button-hole. (Fig. 148.) Between them the respired air passes, and, if the cords are tense, it will be thrown into vibrations, producing a tone, the peculiarities of which will depend on the quantity and quality of air, and construction of the organs below, on the tensility of the cords and the size of the opening between them, the character of the organs and the quality of the air above, and especially upon

the condition of the mucous membrane covering the cords, and forming the edge of the orifice called the glottis. The laryngeal muscles have been mentioned under the proper heads; they are of use in moving the various parts of the larynx upon each other, and thus regulating the tensity of the cords and the size of the opening between them. They also slightly depress the epiglottis, and raise the larynx against it, by which the opening from the larynx is closed.

The *mucous membrane* lines the larynx, and forms above the vocal cords a slight pouch on each side called ventricles; and above these it is again folded inward slightly, forming the superior vocal cords. It is one of the most important parts of the larynx, since upon its perfection the smoothness and clearness of the voice is greatly dependent. A "cold" produces a thickening of it, and a corresponding hoarseness of the voice.

650. The use of the larynx is by closure to retain the air in the lungs while it is compressed, and then to allow it to pass out in a continuous or intermittent stream, which is thrown into vibrations, and thus vocalized, by the vocal cords.

The character of the voice is decidedly affected by the elasticity of the cartilages, ligaments, and mucous membrane of the larynx, but is chiefly influenced by the action of the mind upon the laryngeal muscles. No part of the body exhibits more delicately the influence of the mind. It is really astonishing to observe with what nicety the action of the laryngeal muscles can be controlled. A good singer can contract them to as slight a degree as the twenty-thousandth part of an inch.

651. The *apparatus for articulation* includes the palate, tongue, and lips, which are active, and the roof of the mouth, teeth, and nose, which are passive.

The action of these parts is dependent upon muscular contraction, which is, of course, dependent upon mental influences.

652. The *use of the articulating organs* is to modify the waves of air poured out through them.

653. *Speech* results from the combination of many simple sounds, which are produced by the combined action of the bellows, larynx, and articulating organs.

The different kinds of speech or language are not produced by peculiarities of simple sounds so much as by peculiar combinations of them. The practice of the voice, therefore, in producing the simple sounds or elements, is the first step toward rendering it elastic, and capable in respect to any language.*

654. Two things are necessary *in order that speech may be perfected* : 1st, physical, 2d, mental exercise.

Physical exercise must be regular, gradually increased, and intermitted by proper periods of repose. The physical exercise must be first in producing all the elementary sounds; second in producing all their combinations. At the same time, a perfect state of health of all parts of the body must be induced. Colds *must be very carefully avoided*. Mental exercise must not only be intellectual, but emotional. What is read or spoken must not only be understood, but felt.

Review.

The process of respiration is one of the most interesting in the whole body, such admirable results are attained by such simple means. 1st. A fold of the skin turns inward from the surface of the body, first in the form of a tube, which soon divides almost to infinity, each division terminating in a group of pouches, where the skin has become so delicate as to be hardly recognized as having any thing in common with the protective external coat of the body. 2d. The ribs are gently raised, and instantly the weight of the air in the midst of which we live, pours it down into these pouches, and with zephyr force the lungs are filled to the capacity of the chest. It is then relaxed, and by its elasticity and the gentle traction of muscles restored to its former size, or by their more forcible action reduced below its medium—while with equal step the resilient lungs pour out a corresponding portion of their contents. If the summit of the windpipe is closed and suddenly opened, the air gushes out through the mouth as in coughing, or through the nose as in sneezing, or is modulated into whispering, speaking, singing, whistling, &c.

* The size of this work does not permit a detailed description of the mode of producing all the simple sounds. They are treated upon in the most clear, definite, and learned manner by Prof. Haldeman, in a small work, entitled, "Elements of Latin Pronunciation," which is by far the most satisfactory of any thing I have ever had the pleasure of perusing, and cannot be too highly recommended to student or teacher who wishes to acquire an accurate notion of the mode of pronouncing the words of any language. This work, that classic volume on the voice, by Dr. Rush, the practical and admirable directions of Prof. Russell, and the writings of the great Müller on the voice and ear, are of choice value to every one who has a voice to use.

DIVISION III.

Digestive Apparatus.

ANALYSIS. *General character of digestive apparatus. The Mouth, its framework, teeth, composition, and care of them,—its muscles, and its mucous membrane.—The Salivary glands—Buccal processes—Pharynx, and Œsophagus.—Stomach, its general character, mucous membrane, villi and gastric glands.—Its muscular coats—its serous coat, and the omentum.—Offices of stomach—process of chymification, characters of food which influence the digestive process.—Second stomach—its mucous membrane, follicles, and glands—its muscular coats—its serous coat.—The Pancreas—Liver—Gall-Bladder.—Use of second stomach—process of chylification.—Lacteals, their use.—Colon.—Review.*

655. The *digestive apparatus* consists of a canal, pouched at various parts, and furnished with appendages, the whole being adapted to preparing the food to enter the blood-vessels, and for the rapid introduction of water into the blood.

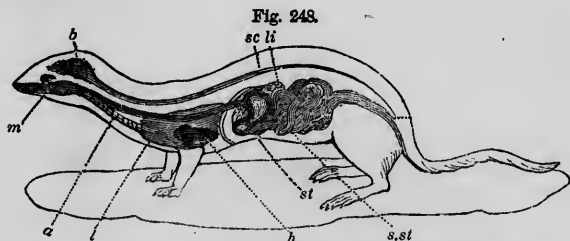


Fig. 240 is an ideal representation of the grand organs of the chest and abdomen: *m*, the mouth; *a*, oesophagus and trachea; *l*, lungs; *h*, heart; *li*, liver; *st*, stomach, *s, st*, second stomach; *b*, brain; *s, c*, spinal cord.

The contents of the digestive canal, are therefore in one sense out of the body, and in another, within it.

656. The *digestive canal* may be divided into five parts, both anatomically and physiologically, which, with their appendages, may be considered under five heads. 1st. The mouth and salivary glands. 2d. The pharynx and Œsophagus. 3d. The stomach. 4th. The second stomach, liver, pancreas, and lacteals. 5th. The colon.

CHAPTER I.

The Mouth and Salivary Glands.

657. The mouth or buccal cavity, is the name given to that portion of the digestive canal, extending from the lips to the base of the tongue, and edge of the soft palate; the operations which take place there are called the buccal processes.

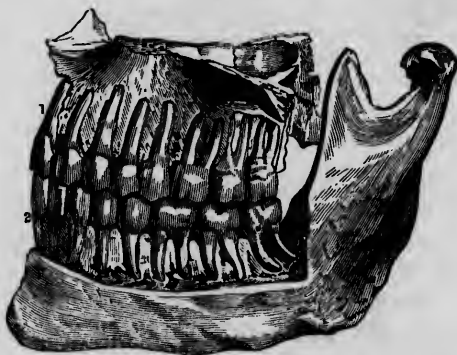
A complete description of the mouth, would include a description of the jaw and palate bones; the teeth, muscles of the jaw, cheeks, tongue and palate, the mucous membrane and glands, and the salivary glands.

The *jaw and palate bones* have been described.

The *teeth* are 20 in number, in the first set, or deciduous teeth, which one after another fall out, and are replaced by the second set, or permanent teeth, which numbers 32.

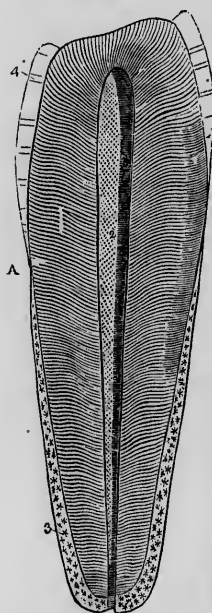
If one of the first set becomes loose, it should be extracted, to make room for its successor; or if it do not become loose, and the second tooth manifests symptoms of its appearance, it should be removed. If the jaw be too small for the full number of teeth, and they are irregular on that account, one should be extracted, and the rest brought into place by the dentist.

Fig. 249.



The eight front teeth, are called incisors; the four next, cuspids, or canine. The next eight the bicusps, and the last twelve, the molars. Each tooth is composed of the crown, which is in sight, the fang or root, which is buried in the alveolar socket, and the neck, which is between the other parts. A perpendicular section of a

Fig. 250.

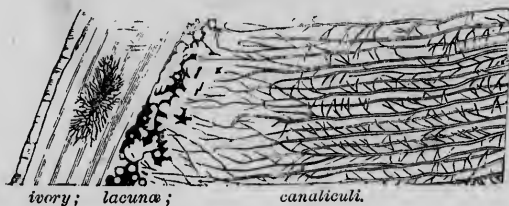


tooth shows that it is composed of three substances. The external part of the crown 4, fig. 250 (the upper part is worn away), is called enamel. It is the most solid portion of the tooth, and forms a kind of glazing. The outside of the fang, is called cementum, is very similar to bone, and like it is covered with a fibrous membrane (periosteum). The inside of the tooth, is called the ivory. It contains a central canal, in which the nerves and blood-vessels, constituting the pulp, are found. From the central canal, a very great number of canaliculi (represented by the curved lines), radiate toward the outside of the ivory, where after many branchings they terminate (see a magnified view of a few of them, fig. 251).

The outside of the ivory is covered with a delicate membrane, which at times is so sensitive, as is also the ivory, that it would seem that nerves must exist here, though they are so delicate, as thus far not to have been seen by the anatomist. This delicate membrane extends between the ivory and enamel, and also the cementum. The composition of each part is peculiar, and its perfection depends very much upon the health and food of the person, while the teeth are growing.

The constitution of a person, the health, and especially the character of the food, both as it respects its composition and digestibility, which is eaten while the teeth are growing, the air inhaled and drink used, are not unimportant.

Fig. 251.



Illus. a.—The teeth usually decay in pairs.

Illus. b.—The teeth of a person frequently differ from each other in constitution; some split easily, others crumble, and others remain

sound, and the pairs of teeth which of course were affected by similar causes, will be found alike in structure.

Illus. c. Inequalities of surface are usually similar in pairs of teeth, and caused by sickness while they were growing, as their history will prove.

Illus. d. The wisdom teeth soon decay.

Inf. Food rich in phosphates should be eaten, while the teeth are growing.

Two reasons probably exist for the good teeth which Scotch people exhibit in Scotland; 1st. The use of oatmeal, one of the most wholesome articles of food that can be eaten; and 2d. The proper temperatures of their food. The teeth are injured by sudden expansion and contraction, by biting hard substances, by forcibly striking against each other, by the deposit of tartar upon them, and of any substances about them.

Illus. a.—Minute checks, like those of a glazed, cracked plate, may be seen in the teeth. Through them the fluids of the mouth can find access to the ivory and cause its decay.

Illus. b.—Bits of the teeth are frequently broken from the enamel, when biting hard substances, or when the teeth forcibly strike each other.

Inf, a.—Hot drinks or food, ice, snow, iced-cream, and other iced desserts, must be injurious to the teeth.

Inf. b.—Cracking nuts, biting pins, straightening hooks, untying knots, and biting off threads with the teeth, must hazard the beauty of the teeth and the health they produce.

Inf. c.—The teeth should be kept clean by the frequent use of a brush, across them, up and down, and within as well as without.

If the teeth have from negligence become coated with tartar, it should be removed; especially should haste be made if it have affected the gums.

If the teeth have decayed, the decayed portion should be *thoroughly* removed, and the cavity filled with gold, if possible. If that cannot be done, the good service which several teeth have rendered me for a dozen years would induce me to use "composition." If that cannot be done, the teeth should be extracted; or if that cannot be, and they affect the breath, the evil may be partly obviated by holding a spoonful of powdered charcoal in the mouth several times per day. Many teeth are extracted that might be filled with profit.

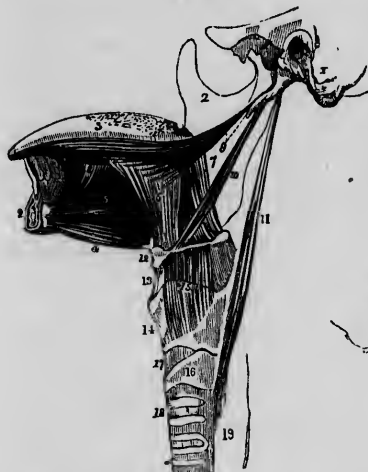
If tooth-washes or powders are used, care should be taken that

they are not, as most are, composed of acids or grits, as one corrodes, and the other scours the enamel, to its great injury.

The *muscles of the jaw* are four; upon each side two, the masseter and temporal without, and two, the external and internal pterygoid within. (See fig. 253.) The former elevate the jaw, the latter move it upward, forward, and from side to side.

The *muscles of the cheeks* are of little use in eating, except the orbicularis oris, which forms the chief part of the lips, and, by expansion and contraction, receives and retains the food.

Fig. 252.



The *muscles of the tongue* form the chief part of that important organ, and support the floor of the mouth between the tongue and jaw.

The *muscles of the palate* serve, in swallowing, to prevent the food from passing into the nasal cavities.

Fig. 253.



The *mucous membrane* is continuous with the skin at the edge of the lips, and forms the entire inner surface of the mouth. Mucous follicles, or glands, abound in it, especially in the back part of the

Fig. 252. The styloid muscles and the muscles of the tongue. 1. A portion of the temporal bone of the left side of the skull, including the styloid and mastoid processes, and the meatus auditorius externus. 2, 2. The right side of the lower jaw, divided at its symphysis: the left side having been removed. 3. The tongue. 4. The genio-hyoideus muscle. 5. The genio-hyo-glossus. 6. The hyo-glossus muscle; its basio-glossus portion. 7. Its cerato-glossus portion. 8. The anterior fibres of the lingualis issuing from between the hyo-glossus and genio-hyo-glossus. 9. The stylo-glossus muscle, with a small portion of the stylo-maxillary ligament. 10. The stylo-hyoid. 11. The stylo-pharyngeus muscle. 12. The os hyoides. 13. The thyro-hyoidean membrane. 14. The thyroid cartilage. 15. The thyro-hyoideus muscle arising from the oblique line on the thyroid cartilage. 16. The cricoid cartilage. 17. The crico-thyroidean membrane, through which the operation of laryngotomy is performed. 18. The trachea. 19. The commencement of the œsophagus.

Fig. 253. The two pterygoid muscles. The zygomatic arch and the greater part of the ramus of the lower jaw have been removed in order to bring these muscles into view. 1. The sphenoid origin of the external pterygoid muscle. 2. Its pterygoid origin. 3. The internal pterygoid muscle.

mouth, and upon the tongue. Those which exist in the mucous membrane of the cheeks and sides of the mouth are thought to form a fluid of the same general nature as the saliva, and are sometimes termed the scattered salivary glands.

The *salivary glands* include three pairs of agglomerate glands, termed the parotid, submaxillary and sublingual—another pair is sometimes counted, called the intra-lingual. The first is found just above the angle of the jaw, in front of the ear. Its duct, called Steno's, opens at the centre of the cheek, and can be felt like a cord upon the masseter muscle. The second pair are situated within the jaw, midway from the angle to the chin, (fig. 178.) Two or three small ducts lead forward and upward, opening into the mouth at the side of the tongue, usually before they have had space to unite into one. The third pair are called the sublingual. They are situated a little in front of the second pair, and by the side of the tongue. Quite a number of minute tubes open upward from it into the mouth. The use of these glands is, to form a fluid called the saliva, composed of many substances in minute quantities, but chiefly of water. That which is found in one of the glands is not similar to that of another; but the distinguishing characteristics, though important, have not yet been well enough made out. The quantity of saliva varies with the movements of the jaws, with the state of the emotions, with the relish of food, and with the effects of habit. The salivary glands are the seat of the disease, called Mumps.

658. The *use of the mouth* is to receive, masticate, and salivate the food, and to pass it and drink into the pharynx.

659. The food is cut and masticated by the teeth, a very important process—the use of which is to prepare the food for easy digestion in the stomach, and also to mix it thoroughly with the saliva.

660. The *use of the saliva* is to moisten the food, and prepare it to be swallowed and digested. It also appears to be the means by which a part at least of the starch eaten, is changed into dextrine and grape-sugar.

Bernard thinks that the saliva which acts thus upon starch is formed by the small and the scattered glands.

Inf. a.—A sufficient length of time should be taken at each meal, to allow the food to be thoroughly masticated, and mingled with the saliva, which also will be some time in being produced.

Inf. b.—That pleasant state of the emotions, which favors the formation of saliva, should always be cultivated at meal times, while food should also be cooked so as to cause their action to be stimulated.

The food when masticated, is gathered by the tongue into a mass, and rolled into the back mouth to be swallowed.

If food be of a liquid character, it should either be eaten with some that is solid, or else *drawn* into the mouth in order that saliva may be mingled with it. This is especially important in case of infants.

CHAPTER II.

Pharynx and Œsophagus.

661. *Pharynx* is the name given to the cavity extending from the nasal fossæ to the œsophagus and larynx, into which it opens below.

It is essentially composed of muscles and mucous membrane. At the sides of the opening from the mouth, the tonsils or amygdaloid glands are situated. They are composed of mucous follicles, and are very subject to become enlarged as one of the effects of colds. The pharyngeal muscles are so situated, that by contraction they pass the substances received from the mouth, down into the œsophagus. The mucous membrane forms the entire surface of this cavity, and partakes of the nature of that which lines the mouth and nose.

662. The *use of the pharynx* is merely as a passage of communication between the nose and larynx, and mouth and œsophagus.

663. *Œsophagus* is the name given to that portion of the digestive canal, which connects the pharynx and stomach.

It is about a foot in length, and about an inch in diameter when distended. It is composed of mucous membrane, and two layers of

Fig. 251.



muscles. One layer of the muscular fasciculi is longitudinal and the other circular. They are both involuntary. The presence of food within the tube is sufficient to excite their successive contraction, which is usually downward, but may take place upward, as in case of vomiting. The mucous membrane is similar to that lining the mouth. The œsophagus is situated behind the trachea, and in front of the spinal column. Its lower extremity turns slightly forward, and to the left, to open into the stomach.

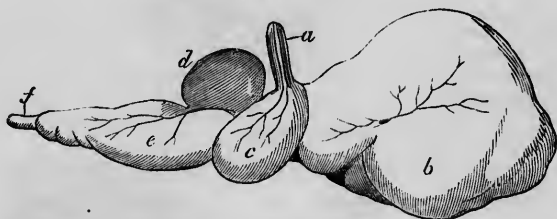
CHAPTER III.

The Stomach.

664. Stomach is the name given to that branch of the digestive canal which receives the food from the œsophagus, and where it is detained to undergo the first process of digestion proper.

In some animals, e. g., the cow and sheep, there are several pouches grouped, as represented by fig. 255. The fourth corresponds

Fig. 255.



to the human stomach. In the fowl, the stomach proper is preceded by the crop and gizzard. (See fig. 50.)

The stomach is *pearl-colored* externally, and internally is of a *yellowish pink* or florid-color, according as it contains much or little blood. Its *size* varies in different individuals, and in the same person at different times, according as the stomach is full or empty, and much or little food habitually taken. When empty it is contracted, and occupies but little space. When distended, its capacity varies from a half pint to a gallon or more. Its *form* resembles that of a bagpipe bellows. (See figures of it.) Its *surfaces* when empty are wrinkled; when distended, the external is smooth and lubricated by serous fluid, the internal presents a velvety appearance owing to the minute long papillæ called villi, with which it is studded. It is *composed* of three layers or coats, one internal mucous, a middle muscular, and an external serous. Sometimes the areolar tissue between the coats is also counted as two coats. The *mucous* membrane is continuous with that of the œsophagus, pharynx, and mouth, and like that abundantly furnished with mucous follicles. But in addition it is composed of villi, which forming the surface, give to it a beautiful fleecy appearance.

The villi are very vascular, as may be judged from fig. 258, a partially ideal representation of the capillaries in a papilla of the tongue. The use of the villi seems to be to present an extensive surface for the absorption of substance from the contents of the stomach by the blood-vessels. The mucous membrane is also composed of gastric follicles, which are similar to the mucous follicles in general appearance, but which secrete a peculiar fluid called gastric juice. Their activity is very much increased at the time of digestion, when their fluid is largely required for the digestion of parts of the food.

The *gastric fluid* is peculiar to the stomach, has much the general appearance of water, a slightly peculiar smell, and an acid or alkaline, slightly saltish taste. It has the property of curdling milk; hence the fourth stomach (rennet) of the calf is used for this purpose in making cheese. It prevents meat from putrefy-

Fig. 256.

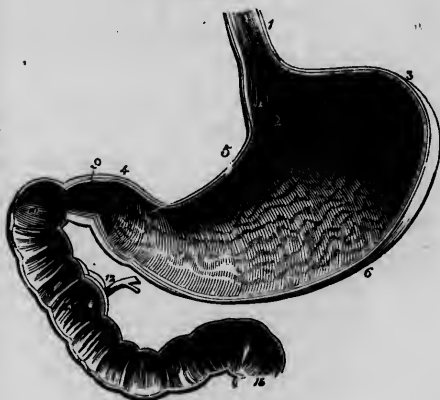


Fig. 257.



Fig 258.



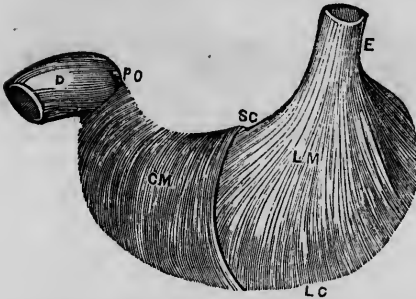
Fig. 256 represents a section of the stomach, and a view of its internal surface: 1, oesophagus; 2, oesophageal orifice of stomach; 3, its larger, 4, its smaller extremity; 6, its greater, 5, its lesser curvature; 9, pylorus; 10, 11, 14, 15, second stomach; 12, pancreatic duct; 13 opening of the pancreatic and choledoch duct.

Fig. 257, another view of stomach: 1, oesophagus; 2, oesophageal or cardiac orifice closed; 3, larger, 7, smaller extremity; 4, greater, 9, lesser curvature of the stomach; 5, line of attachment of the omentum major; 6, muscular coat; 7, mucous coat; 11, pylorus; 10, 12, second stomach.

ing, and can remove all appearance of taint from it in a short time. Its peculiar action upon food is yet an enigma. It is formed from the blood, and, of course, its formation depends upon the flow of healthy blood to the stomach, and the action of intellectual and emotional influences.

The *muscular coat* of the stomach, fig. 259, is composed of three

Fig. 259.



coats, which are not as distinct as in "tripe," where they can readily be seen. By alternate contractions of the different parts of this coat, the contents of the stomach can be moved about, or compressed in, or pressed out from, it.

The *serous* is also called the peritoneal coat. From the line 5, fig. 251, the serous coat can be traced down in front of the

second stomach, where it is called the omentum major; on account of its collections of fat cells, it presents a beautiful, netted appearance.

Fig. 260.

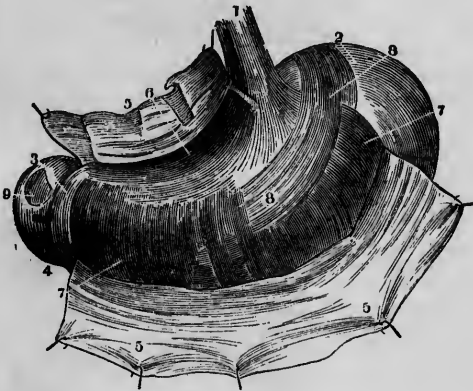


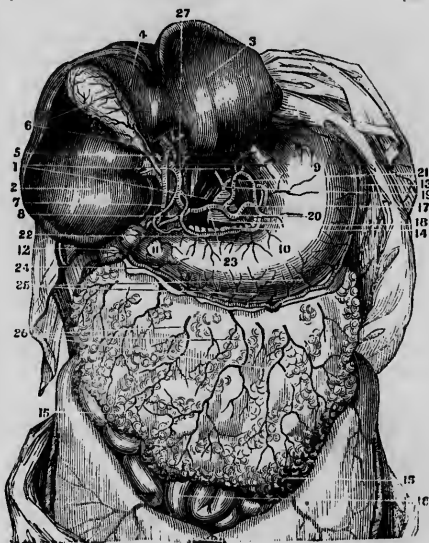
Fig. 260. Serous coat 5, turned back from 6, a portion of longitudinal, 7, circular and 8, oblique muscular fasciculi.

This is the part first observed when the abdomen is opened, and commonly called the caul. Butchers often take it from a fat animal, and spread it on the quarters of a lean one.

Fig. 261.

Fig. 261, 1, pillars of diaphragm; 2, liver turned up; 3, left, 4, right lobe; 6, gall-bladder; 9, 10, 11, stomach slightly depressed; 13, the spleen; 15, the omentum major; 16, portion of second stomach, seen below the edge of the omentum.

The stomach has two openings. One, called the œsophageal or cardiac, is about one-third the length of the stomach, from the large extremity. The other, called the pyloric or hepatic orifice, is at the termination of the small extremity of the stomach. The first is chiefly distinguished by a thicker ring of muscular fibrils than the rest of the œsophagus or stomach.

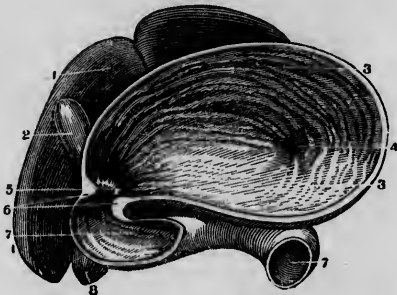


The second, or pyloric orifice, exhibits a fold of the mucous membrane, a kind of "tuck," in which a strong mus-

Fig. 262.

Fig. 262 represents a transverse section of the stomach, the eye being below, and looking upward; 3, upper part of inner surface of stomach; 4, cardiac, 5, pyloric orifice; 6, muscular fasciculus; 7, second stomach; 1, under surface of liver; 2, gall-bladder.

Fig. 263 represents, 1, section of small extremity of the stomach; 2, folds, villi and mucous follicles; 3, pylorus; 4, muscle; 5, second stomach; 6, opening of the duct from the liver.



cular fasciculus is found, as shown by the figures of it. (See also fig. 267.)

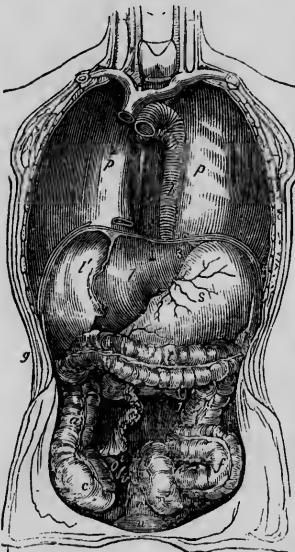
Fig. 263.



The *stomach* is situated directly below, and in contact with, the diaphragm, on the left side. The œsophageal orifice is a little to the left of the centre of the body. On the right, the stomach is situated beneath the left lobe of the liver, the pyloric orifice being a little lower than the cardiac. Its position, isolated, is seen in fig. 38; with the liver turned

up, (fig. 255;) and in natural position in fig. 264, and in Plate 7.

Fig. 264.



The position of the stomach varies with inspiration and expiration, and as it is filled and emptied. When filled, it distends the abdomen, and prevents the easy and perfect depression of the diaphragm, while also it enables the expiratory muscles to act with more energy.

The stomach is suspended in its position by the peritoneal membrane, thickened at certain places into ligaments.

665. The *use* of the *stomach* is to retain the food exposed to the action of a uniform temperature of about 100 degrees, the saliva, and the gastric juice by which the first process of digestion is accomplished.

Fig. 264. *s*, stomach; *l*, liver, the left portion of which *h*, covers the right portion of the stomach; *o*, œsophagus; *h*, aorta; *p*, pulmonary cavities; *k*, spleen; *a*, *t*, *f*, colon.

The precise operations that take place in the contents of the stomach, have not been as yet perfectly determined. Only general conclusions can now be stated. For these we are chiefly indebted

ed to Dr. Beaumont, who during several years experimented on Alexis St. Martin. This young man was injured in the year 1822, in the State of Michigan, while gunning. The buck shot and powder of a companion's gun accidentally discharged, tore off a portion of his side, leaving an opening into the chest and the stomach itself. When the wound healed, the edges of the stomach adhered to those of the side, and thus he recovered perfect health, with an opening about an inch and a half in diameter, into the stomach. He lived a score of years, and many examinations and experiments were made. A synopsis of Dr. B.'s observations is all that can be given. 1st. When food is taken into the stomach, the mucous membrane becomes flushed from the increased flow of blood to it. 2d. The gastric juice soon begins to make its appearance in minute drops like perspiration on the face. It continues to flow for the space of five minutes to half an hour, after which the flushed appearance of the stomach begins to fade. 3d. The stomach begins to contract and move about its contents and mix them with the gastric juice. 4th. The temperature of the stomach is somewhat elevated during digestion; being 100° to 102° . Gradually, the food becomes changed into a grayish paste, which little by little passes into the second stomach, and the first stomach remains empty.

Food masticated and salivated, was digested equally as well when passed into the stomach direct, as when swallowed. The gastric fluid taken from the stomach, and mixed with food which was kept of a proper temperature, caused it to be changed into a paste, resembling the chyme of the stomach.

The *length of time required for the digestion of food*, depended upon the kind of food, the manner in which it was cooked, the quantity of it, the thoroughness of the buccal process, the health of the stomach, the necessity for food, the simultaneous action of other parts, and mental influences. The following table exhibits the average time required for the digestion of several kinds of food cooked in several ways. It may not be a guide for others.

If from any cause food remained a long time in the stomach, it would excite disease.

Inf. It is far better to throw food away, than to eat it improperly, or when not needed; for it is then not only wasted, but worse still, it produces disease.

Dr. B. testifies, that when the *food was relished*, the fluids would flow into the stomach with the same facility as the saliva does into the mouth.

Inf. Of wholesome kinds of food, that is most so, which is best relished.

TABLE.

EXHIBITING THE AVERAGE TIME OF DIGESTION OF CERTAIN ARTICLES OF DIET.

Articles.	Preparation.	Time.	Articles.	Preparation.	Time.
		h. m.			h. m.
Pigs' feet, soused, . .	Boiled,	1	Soup, chicken, . . .	Boiled,	3
Rice,	Boiled,	1	Pork steak,	Broiled,	3 15
Tripe, soused, . . .	Boiled,	1	Pork recently salted,	Broiled,	3 15
Apples, sweet, . . .	Raw,	1 30	Oysters, fresh, . . .	Roasted,	3 15
Trout, salmon, fresh,	Boiled,	1 30	Mutton, fresh, . . .	Roasted,	3 15
	Fried,	1 30	Bread, corn, . . .	Baked,	3 15
Venison steak, . . .	Broiled,	1 35	Carrot, orange, . . .	Boiled,	3 15
Sago,	Boiled,	1 45	Beef, with mustard,	Boiled,	3 15
Apples, sour, mellow,	Raw,	2	Sausage,	Broiled,	3 15
Cabbage and vinegar,	Raw,	2	Beef, fresh, lean, dry,	Roasted,	3 30
Codfish, cured, dry,	Boiled,	2	Bread, wheat, fresh,	Baked,	3 30
Eggs, fresh,	Raw,	2	Butter,	Melted,	3 30
Liver, beef's, fresh,	Broiled,	2	Catfish,	Fried,	3 30
Milk,	Boiled,	2	Cheese, old, strong,	Raw,	3 30
Tapioca,	Boiled,	2	Eggs, fresh,	Boiled,	3 30
Milk,	Raw,	2 15	—,	hard,	
Turkey, wild, . . .	Roasted,	2 18	—,	Fried,	3 30
—, domesticated,	Boiled,	2 25	Flounder, fresh, . .	Fried,	3 30
—,	Roasted,	2 30	Oysters, fresh, . . .	Stewed,	3 30
Potatoes, Irish, . .	Baked,	2 30	Potatoes, Irish, . .	Boiled,	3 30
Pig,	Roasted,	2 30	Soup, mutton, . . .	Boiled,	3 30
Parsnips,	Boiled,	2 30	Soup, oyster, . . .	Boiled,	3 30
Meat hashed with } vegetables, }	Warm'd,	2 30	Turnips, flat, . . .	Boiled,	3 30
Lamb, fresh,	Broiled,	2 30	Beef fresh, lean, } with salt only, }	Boiled,	3 36
Goose,	Roasted,	2 30	Corn, green, & beans,	Boiled,	3 45
Cake, sponge, . . .	Baked,	2 30	Beets,	Boiled,	3 45
Cabbage head, . . .	Raw,	2 30	Beef, fresh, lean, .	Fried,	4
Beans, pod,	Boiled,	2 30	Ducks, domesticated,	Roasted,	4
Chicken, full-grown,	Fricas'd,	2 45	Fowl, domestic, . .	Boiled,	4
Custard,	Baked,	2 45	—,	Roasted,	4
Apples, sour, hard,	Raw,	2 50	Salmon, salted, . . .	Boiled,	4
Oysters, fresh, . . .	Raw,	2 55	Soup, beef, vege- } tables & bread, }	Boiled,	4
Bass, striped, fresh,	Broiled,	3	Veal, fresh,	Broiled,	4
Beef, fresh, lean, rare,	Roasted,	3	Pork, recently salted,	Fried,	4 15
—steak,	Broiled,	3	Beef, old hard, salted,	Boiled,	4 15
Corn cake,	Baked,	3	Cabbage,	Boiled,	4 30
Dumpling, apple, .	Boiled,	3	Ducks, wild,	Roasted,	4 30
Eggs, fresh,	Boiled,	3	Suet, mutton, . . .	Boiled,	4 30
—,	soft,	3	Veal, fresh,	Fried,	4 30
Mutton, fresh, . . .	Broiled,	3	Pork, fat and lean,	Roasted,	5 15
—,	Boiled,	3	Suet, beef, fresh, .	Boiled,	5 30
Pork, recently salted,	Boiled,	3			

The appetite, especially of the sick, and those who actively exercise the nervous system, frequently craves a particular kind of food, and if there is no objection, it is very important sometimes that it be eaten; for different kinds of food serve different purposes, and frequently the best kind is indicated by the organic appetite.

Cooking affected the food in two ways: 1st, by changing its character; and 2d, by rendering it more or less difficult for the juices of the mouth and stomach to saturate the food.

Inf. As well relished food affects the mind favorably, and badly digested food produces derangement of the stomach, and of course unfavorably affects the mind, causing irritability, &c., the art of cooking is not to be considered as unworthy the notice of dignified science, since by means of it, itself can be advanced.

The *quantity* of food taken, had a great effect, since the gastric juice formed was in accordance with the quantity of food required by the system, not with that taken, and any superabundance very much retarded digestion, and tended to derange the stomach.

But when a quantity of food such as would reasonably distend the stomach was required, its bulk was an advantage.

Inf. It is not as well to eat a little and often, as more unfrequently, and in larger quantity; as the relish will be greater, the food will be chewed with greater avidity, the saliva and gastric juice will flow more plentifully, and the stomach can easier contract upon the food.

Hence it is often well to eat substances with the food which are useful only by distending the stomach.

When the system is exhausted, the quantity of food must not be limited so much by the amount required, as by that which can be digested, which is of course small, as the sources of the saliva, gastric juice and nervous influences, &c., are in common with other parts exhausted, and the whole must gradually recuperate by mutual action of the parts.

If the *food was not properly masticated*, the time required for its digestion was not only prolonged, but the stomach was often diseased in the mean time.

The *health of the stomach* would usually manifest itself by the appetite. When it was deranged, the food would either be a long time in digesting, or would not be digested at all.

Inf. It is worse than useless to eat food when there is no appetite.

When sick, persons frequently think that a little food can do no harm, and is absolutely necessary; but the testimony of Dr. B.

proved that if there is not an appetite, the use of any is always injurious. Rest of all parts, digestive organs, as well as any, is absolutely required for restoration to health. If the disease is slight, and an appetite of a healthy character exists, it may be carefully gratified to a slight degree. But in all ordinary cases, entire abstinence is one of the best remedies in the outset of a disease.

In any part of it, nothing is more important than the strictest regard to diet, in accordance with proper medical advice.

The *temperature* of food and drinks materially affected in every respect the process of the digestion. A low temperature at once retarded, or altogether stopped it; while heat debilitated the stomach.

Inf. The use of iced water, and cold desserts at meal times, must be injurious.

There is probably at present no more frequent cause of dyspepsia, than the iced drinks taken with repasts, and the iced desserts which have become so common. The substances cannot be digested at once, and must derange the stomach by their presence. Hot drinks and hot food, if not as bad, are nearly so; and what can be more deleterious than first swallowing into the delicate stomach substances so hot, they cannot be with comfort held in the mouth, and in a few moments passing down others of almost icy coldness.

A very *small quantity* of *spices* sometimes seemed to hasten the process of digestion, while in large quantities they always produced derangement.

Inf. The mustard and pepper poultices which some persons apply to their uncomplaining stomachs, must be poisons in disguise.

"*Any kind,*" of "*intoxicating drinks*" "*wine*" "*beer,*" (cider might as well have been specifically mentioned,) always would derange the stomach if used for a few (only three or four) days consecutively, in very small quantities.

Inf. Total abstinence is the *only* rule of health.

It must not be supposed that all these derangements of the stomach were manifested by pain. Alexis was as unconscious of them as others who equally suffer in ways which they do not attribute to the right cause. The stomach does not directly complain till it is very bad.

The vigorous *action of other parts* at the time of digestion, retarded or altogether stopped it—while gentle action of other parts facilitated digestion.

Inf. Laborious muscular or engrossing mental action, should not immediately precede, follow, or be associated with the chymific process.

Inf. Food should not be eaten immediately before sleeping.

If food have not been taken for some time, and is demanded for the nutrition of the system, a small portion of very easily digested food may be eaten. But nothing can be worse for the health, or more suicidal to beauty, than the indigestible food eaten without appetite at parties.

The *state of the mind* was found to be of the greatest consequence, a fit of anger would abruptly stop the digestive process for an hour or more, while a pleasant state of the emotions was to an equal degree favorable.

Inf. Enlivening anecdotes, and sociability should be the sauce of every repast.

666. The process of digestion results in the forming of two classes of substance, one of which is absorbed by the vessels of the stomach, and passes directly into the portal veins—the other is a gray paste termed chyme, and gives the name of chymific to the digestive process that takes place in the stomach.

What portion or kind of the food is absorbed from the stomach, has not been definitely determined. But the contents of the portal vein, and the experiments of Bernard, convince us that some of the food is absorbed. It may be, and probably is in part, that which has been prepared by the action of the saliva. The gray paste includes the rest of the food.

667. The stomach is also of use for receiving water, and allowing it to be absorbed into the blood-vessels.

Dr. B. observed that if St. Martin was very thirsty, water would vanish from the stomach almost as quickly, as a sponge could drink it up, while if he were not, it would remain a long time. If the food were too dry when swallowed, the gastric fluid would not flow freely, till drink had been taken, and the consistence of the food made similar to paste. If the food were thin, like gruel, digestion would not go on till part of the fluid was absorbed. St. Martin was inclined to drink too much, but when governed by his thirst, satisfying it, but not satiating it, he was usually right.

CHAPTER IV.

The Second Stomach, Liver, Pancreas, and Lacteals.

668. The *second stomach*, is the name given to that long portion of the digestive canal, which exists between the stomach and colon.

Its *diameter* varies from half an inch, to two inches, averaging an inch and a fourth. Its *length* is from 5, to 30 feet, averaging 16, to 20. It is *composed* of an internal mucous, a middle muscular, and an external serous coat.

The mucous is continuous with that of the stomach. Its inner surface is furnished with papillæ, and exhibits the mouths of numerous mucous follicles. In the upper part of the canal, another kind of large follicles, called *Brunner's glands*, exist. They are supposed to secrete a fluid, similar to the pancreatic juice.

Peyer's glands, is the name given to parts found in the mucous membrane, having the appearance of closed follicles. They are solitary in various parts of the canal, and aggregated in the front part of the mucous membrane of the lower portion of the canal. The use of either kind is not known. *Lieberkuhn's glands*, is the name given to minute follicles, which in great numbers exist throughout the mucous membrane of the second stomach and colon; their use is not known.

The *mucous membrane* thus composed, is formed into a great number of folds, called *rugæ*, some of which are a complete circle, but most only a part of one; they serve a double purpose of valves, to check the passage of the chyme, and to expose more surface to it. The inner surface of the canal is thus made much longer than the external.

The *muscular fasciculi*, are of two kinds; one circular, the other longitudinal. By the successive contraction of the former, the contents of the canal are pressed onward. By the action of the latter, the canal is shortened, and the passage of its contents facilitated.

The *serous coat* envelopes the muscular, and extending back forms what is called the mesentery, the two layers of which spreading out in front of the spinal region, suspend the second stomach thereto, restraining it somewhat, but also allowing much latitude of motion.

669. The *second stomach* is arbitrarily divided into three portions. The upper twelve inches is called the duodenum; the upper half of the remainder is called the jejunum; the lower half the ileum.

670. *Liver*, is the name given to the organ, by which the bile is formed, or separated from the blood.

Fig. 265.

Fig. 266.

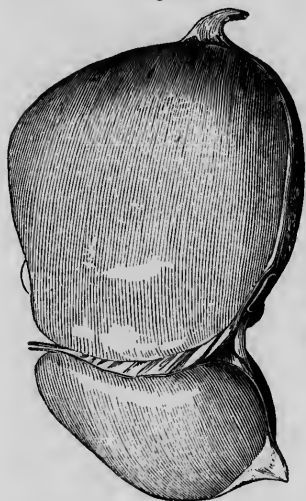


Fig. 265. Upper surface of the liver.

Fig. 266. Inferior surface of the liver.

It is the largest gland in the body, its average weight being between 3 and 5 pounds. It extends from the diaphragm of the right side, past the centre of the body, for three or four inches into the left side. Its right lobe is thick, but its left one is very thin. It is convex above, and concave below. Its entire edge being very thin. It is composed of cells (probably two kinds), fibrous tissue, capillaries, arteries, veins of two kinds, lymphatics, nerves, and ducts, through which the bile passes out, the whole being inclosed by serous membrane.

671. The *use of the liver* is twofold : 1st. It perfects the blood received from the stomach, which contains parts of the digested food. 2d. It removes or forms, from the blood, bile, which serves two purposes,—it assists in the second process of digestion, and being removed from the blood, it is purer and more healthy.

The liver is probably a double gland, and composed in part of two kinds of cells, by one of which the bile is removed, and by the other the blood perfected, since substances are found in the blood

that flows from the liver, which did not exist in that which flows into the liver—viz., liver sugar.

672. The *bile* is an orange green limpid fluid, rather sweetish than bitter, which probably exists in the blood as bile in very minute quantities, and is merely separated by the action of the liver. Its precise use has not been determined.

673. The *gall cyst or bladder* is the name given to a conical pouch of one to three ounces capacity, adherent to the under surface of the liver. It contains the gall, and by a short duct connects with the one leading from the liver, and extending to the second stomach. (See fig. 267.)

Fig. 267.



Fig. 268.

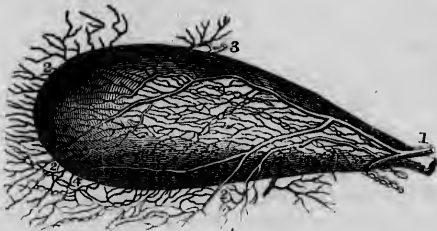


Fig. 268. Gall cyst, with capillaries partially separated from it.

Some think that the gall bladder is merely a reservoir for the bile, which there becomes inspissated and bitter; but the better opinion is, probably, that which considers the gall bladder as a crypta or follicle, in which the gall is secreted.

Fig. 267. *p*, pylorus; *d*, duodenum; *c*, choledoch duct, formed of *s*, the gall duct united to the hepatic duct; *g*, gall bladder; *o*, pancreas.

674. Gall is the name given to a dark green, ropy, very bitter fluid, which with the bile, is poured down into the second stomach to be mixed with the chyme, and assist in chylification.

675. Pancreas is the name given to a gland which forms the pancreatic juice.

It is frequently called the sweetbread. It is about 10 inches long, and from one inch to $2\frac{1}{2}$ wide, and about an inch thick. It is composed of a multitude of cells grouped about the minute branches of a duct of vessels, nerves and fibrous tissue. It is situated just back of the lower part of the stomach, very nearly in the centre of the body.

676. The pancreatic juice is poured out through the pancreatic duct into the second stomach, and is at present believed to be useful in forming fat from certain portions of the chyme.

677. The *use of the second stomach* is to receive chyme from the stomach, bile, gall, and pancreatic juice from the organs which form them, and mix the whole together, and with the fluids formed by its own glands—and slowly pass the resulting compound over the extensive surface of its mucous membrane. The consequence of which is the transformation of a greater or smaller portion of the chyme into a whitish fluid called chyle, which is absorbed by the lacteals or blood-vessels, or both.

678. Lacteals is the name given to those lymphatics, which in almost infinite numbers commence in the villi of the second stomach.

Fig. 269.



Fig. 270.



Figs. 263, 264, represent two modes by which the lacteals have been supposed to commence. A multitude of cells exist about their extremities, and it is supposed that they take up the chyle from the canal, and by rupturing, yield it improved to the lacteal vessels, which can be traced in a short distance to glands, from which other

tubes lead to other glands, till at last all the lacteals of the second stomach terminate in a single tube which leads up in front of the spinal column, and terminates in the neck veins, where the chyle, somewhat changed, is poured into the blood. (See fig. 40.)

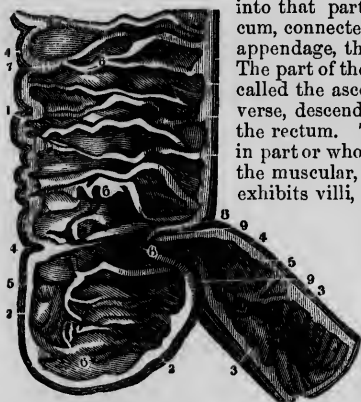
679. The *use* of the lacteals is to absorb the chyle from the second stomach, and after changing it somewhat, and preparing it, to pour it into the blood-vessels.

CHAPTER V.

Colon.

680. The *colon* and *rectum* are the names given to the remainder of the digestive canal, below the ileum.

Fig. 271.



The ileum 3, opens by a kind of valve 8, into that part of the colon called the cæcum, connected with which is the vermiform appendage, the use of which is unknown. The part of the colon which leads upward is called the ascending, then follows the transverse, descending, and sigmoid flexure, and the rectum. The whole colon is composed in part or wholly of three coats, the mucous, the muscular, and the serous. The mucous exhibits villi, mucous follicles, and Lieberkuhn's glands. In the villi a few lacteals take their rise. It is formed into folds of considerable size. The muscular fasciculi are circular and longitudinal. The former are gathered into bundles to a certain degree, which has the effect of pouching the colon. The longitudinal fas-

ciculi are gathered into three bundles, which extend somewhat spirally along the colon. In certain parts the serous coat envelopes the colon, and forms a mesentery, but at other parts, it merely covers one side of the colon, binding it down in its place.

681. The *use* of the colon is chiefly to serve as a reservoir for the excretions of the digestive canal, and for that portion of the chyme which is not changed into chyle.

682. Its healthy action is of vital consequence, and is dependent on the use of proper and bulky food, upon muscular exercise, mental influences, the clothing and habit.

If only such a quantity of food is taken as is digested and taken up by the lacteals, there is not usually enough excreted to give the colon the stimulus which results from distension. Exercise, by producing substance to be excreted, favors the action of the colon. Mental influences through the nervous system disturb every part, and the digestive organs particularly. If the clothing about the waist be tight, it must tend to prevent substances from leaving the ascending colon, or if they do, the pressure will tend to obstruct their passage from the transverse, into the compressed descending colon. Habit of daily action is especially necessary in case of the organs under consideration.

Review.

A comprehensive view of the digestive apparatus, exhibits a very long pouched, mucous membrane canal, folded inward from the external skin. It is formed into rugæ, villi, and follicles, and presents not less than a thousand square feet of surface. It is surrounded with muscular fasciculi, which are covered with a serous coat where the canal is disconnected from other parts, and with areolar tissue elsewhere. Its entrance is furnished with an apparatus for grinding the food, and throughout its extent, various fluids are poured into it from appendages connected with it. A composition of food and digestive fluids is thus produced, the elements of which unite with each other, producing new compounds, which in a liquid form bathe the villi, in which the delicate blood-vessels and lacteal roots exist, ready to absorb whatever is adapted to the wants of the system.

The appendages are follicles or compound glands, according to the amount of fluid required, and the space which can be allowed. They are situated where it is convenient they should be, either as simple glands in the mucous membrane itself, or as agglomerate glands in some space otherwise unoccupied, and longer or shorter tubes communicate with them. The fluids required differ in their nature, and different glands exist. Some of the fluids can act well together, others consecutively. The food is therefore detained in certain parts of the canal.

The lower portion of it is a large reservoir for the excretions it eliminates, and the useless or undigested portions of the food.

DIVISION IV.

ANALYSIS.—*The blood contains several kinds of useless substances.—Several glands are needed to eliminate them.—The Lungs, Liver, Second Stomach, Kidneys, Skin.—The first three have other duties.—The last two are special eliminators.—Structure particularly described.—Kidneys eliminate water, nitrates, sulphates, phosphates, calcium, &c.—The skin eliminates water, oil, horny substances, and a large amount of substance as yet unanalyzed.—Of great importance intrinsically, and still more worthy of care from its liability to exposure.—Care which should be taken of it.—Review.*

Eliminatory Apparatus.

683. *Eliminatory apparatus* is the name given to those parts of the body by which useless substance is removed from it. They may be considered under five heads—1st, the lungs; 2d, the liver; 3d, the second stomach; 4th, the kidneys; 5th, the skin.

CHAPTER I.

The Lungs.

684. The *lungs* are organs eliminating carbonic acid, a deadly poison; heat, when the temperature of the body is too elevated; water, alcohol, and various other obnoxious substances.

CHAPTER II.

The Liver.

685. The *liver* is an eliminating organ in respect to the yellow matter of the bile, and also, in all probability, of carbon and other substances.

By some it is doubted whether the liver is, properly speaking, an eliminating organ, for they think that the bile is united with the food, and taken back into the circulation again, in which case it would be properly called a secretory gland. But in summer, I do not doubt that the liver is the chief eliminator of carbon. It is probable that the liver is composed of at least two, and perhaps three classes of parts, blended or interwoven, and useful for as many purposes.

CHAPTER III.

Second Stomach and Colon.

686. The *digestive canal* below the stomach, serves the double purpose of digestion and elimination. The amount removed from the system in this way is considerable.

How the excretion passes from the system is not understood. It is probably by the action of some of the follicular glands of the mucous membrane.

CHAPTER IV.

The Kidneys.

687. *Kidneys* is the name given to two glands, set apart for the especial purpose of eliminating.

Fig. 272.

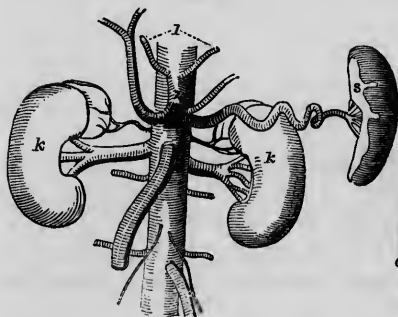


Fig. 273.

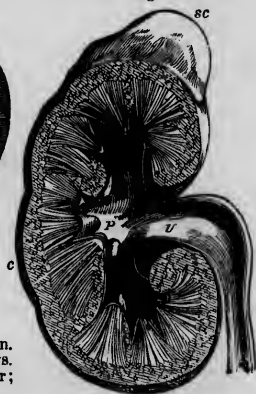
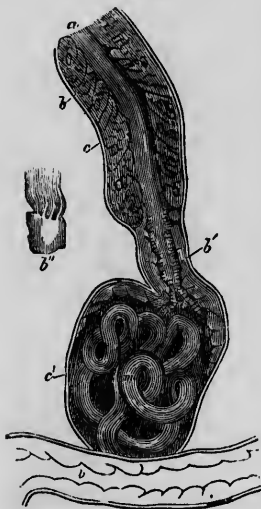


Fig. 272. 1, abdominal aorta; k, kidneys; s, spleen.
 Fig. 273, represents a section of one of the kidneys.
 t, tubular portion; c, cortical part; p, pelvis; u, ureter;
 sc, supra renal capsules.

Fig. 274.



There are two kidneys, of similar size, shape and surface, to those of the mammalia generally. A central cavity is called the pelvis, and the tube leading therefrom the ureter. The tubular portion is composed of minute tubes, which lead out to the cortical part, near which they divide and subdivide, terminating in what are called malphigian bodies, (fig. 274.) within which the minute blood-vessels exist, through the sides of which at least the watery components of the blood may ooze, while by the cells lining the tube, other substances may be excreted.

688. The *use of the kidneys* is to remove any superabundance of water, phosphates, sulphates, nitrates, calcium, or magnesium.

689. By eliminating water, the kidneys to a certain degree regulate both the production and the distribution of heat, and all those processes which depend on the quantity of the circulating blood.

CHAPTER V.

The Skin and Appendages.

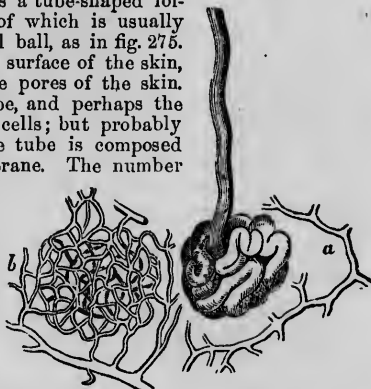
690. The *action of the skin* as an *eliminating organ*, depends upon its perspiratory glands, which are the chief eliminating, cutaneous organs, and the radiation of heat from its surface.

Fig. 274. *a*, renal tube leading from the pelvis to the malphigian body *c'*, in which the capillary *m*, is seen; *b*, a blood-vessel external to *c'*, with which *m* is connected; *b'* indicates cells found upon the inside of the tube *a*, and part of the body.

Fig. 275. *a*, convoluted perspiratory tube; *b*, network of the capillaries surrounding it.

Fig. 275.

A perspiratory gland is a tube-shaped follicle, the inner extremity of which is usually convoluted, forming a small ball, as in fig. 275. The tubes open upon the surface of the skin, forming what are called the pores of the skin. The outer part of the tube, and perhaps the whole length is lined with cells; but probably the inner extremity of the tube is composed merely of basement membrane. The number of the glands in the skin is almost innumerable. Wilson has supposed that collectively they would form a tube, twenty-eight miles long; but one hundred miles, would have been nearer the truth.



691. The use of the *perspiratory glands*, is twofold. 1st. To eliminate solid excretions. 2d. To eliminate water, which by evaporating eliminates, or rather carries off heat.

More or less water is always eliminated with the solid excretions, which are dissolved in it. When it evaporates a part of the solid substance is also carried with it, the remainder forms, with the oil of the skin, a kind of gummy substance.

692. When the substance eliminated is too small in quantity to be readily noticed, it is called the *insensible perspiration*; when it appears in minute, or larger drops, it is called the *sensible perspiration*, or in case of animals, sweat.

The perspiration can always be seen, by holding a piece of glass near the skin, as the moisture will be deposited on the glass. Its amount in the twenty-four hours is almost incredible. Sanctorius, an Italian physiologist, weighed himself, and all he ate and drank, several times per day, for 30 years. He concludes, that a weight of substance equal to five-eighths of what he ate and drank, was eliminated by the skin and lungs. Lavoisier and Seguin, French physiologists, inclosed themselves in glazed bags, with the opening glued about the mouth, and thus were able to ascertain how much weight of substance the skin eliminated in their cases, which was about one pound in twenty-four hours, in the most unfavorable, and five pounds in one hour, in the most favorable circumstances.

I have weighed myself and others at various times, and been surprised at the results. It is a very instructive lesson, for a person to weigh himself half a dozen times per day, before and after his repast, for a week, at the same time making out a table of the weights, temperatures, weather, his feelings, etc. He will find that when he loses the most by the skin, he will enjoy the best health, physically and mentally. The most I have ever observed a person to lose, was four pounds in one hour and thirty-five minutes. The circumstances were very favorable. It is not necessary that the skin be usually so active as this; from two to four pounds in the twenty-four hours, ought to be removed by the skin.

Inf. The perspiratory glands are among the most important organs of the body.

It is sometimes supposed that either different glands, or different parts of the same gland, are concerned in the two offices of removing the solid and fluid perspiratory excretions.

693. The *character of the perspiration* has never been determined by accurate chemical analysis.

This excretion is evidently a very compound substance, which varies in its qualities at different times, being the product, as it doubtless is, of the decomposition of several different tissues. When retained in, or taken into, the body, it acts as a violent poison. Indeed, it is supposed that if the entire action of the skin should cease, death would result as quickly as when the action of the lungs is prevented. The nature of this excretion is abundantly evident to the sense of smell in any close sleeping apartment; though it is here mingled with the excretions of the lungs. Clothing having become charged with cutaneous excretions, is exceedingly unpleasant. These excretions being absorbed from the air breathed, and the clothing too unfrequently changed, are very deadly in their effects. Hence why fevers are so common and so deadly in crowded, ill ventilated houses. Hence why fatal diseases prevail more in the lower than in the upper stories, and why they are more fatal in warm weather when the heat causes the rapid decomposition of the animal excretions.

Inf. a.—Apartments should always be ventilated, not only that pure air may be breathed, but that the exhalations of the lungs and perspiration from the skin may be removed.

Inf. b.—Clothing should be so often changed and cleansed, that absorption of any excretion cannot take place to an injurious degree.

Clothing includes that of the night as well as of the day, and of course the above inference applies also to bedding, which should daily be aired, and often thoroughly cleansed. To sleep in beds "made" immediately after their occupants have risen, is to be constantly in contact with contagion.

694. When the *perspiratory glands perform their functions* in a healthy manner, the effect is manifested in the action of every other part of the body, especially the nervous system.

695. When the *action of the perspiratory glands is checked*, two evils result: 1st. An accumulation of poison in the system, to a greater or less degree, takes place. 2d. To mitigate the first evil, some of the other eliminating organs are caused to increase their action, and take on a kind of action that is not perfectly natural to them, and which will very soon produce disease in them.

The state of the system thus produced is, in common language, said to be caused by "a cold," because cold is the most common cause; but unusual heat, and several other evils, also derange the action of the cutaneous glands. The effect of "a cold" is most frequently manifested by the upper part of the air passages, when a person is said to have "a cold in the head." If the air passages are more extensively affected, the "cold" is said to be "settled on the lungs." But the cause is equally "a cold," when it manifests itself elsewhere, though it is then frequently spoken of under some other name, *e. g.*, summer complaints.

Inf. a.—In all cases where derangement of the functions of the skin is the cause of disease, especial attention should be paid to their restoration.

Inf. b.—To prevent coughs, summer complaints ("colds" are not the only cause of them), &c., the healthy action of the skin must be carefully preserved.

696. The *action of the respiratory glands is dependent* upon—1st, the circulation of blood; 2d, the health of the glands; and 3d, the cleanliness of the surface of the skin.

That there may be a proper *circulation of blood in the skin*, it must be rubbed, the muscles exercised, the organs of circulation preserved in health, congestion or a too active circulation of blood

in any part prevented, mental influences favorable, and a proper temperature preserved in the skin. As this temperature is in part dependent on the production of heat, the character of the food, air, and water used, are important to be considered in this connection, as well as the clothing by which heat is preserved, and the external sources from which it is received. To prevent "taking cold," it is very important to have pure cool air received for the production of heat, and warm clothing worn for its preservation. One reason why radiated heat is better than conducted, is, probably, that pure cool air may also be breathed, while heat is received by the body. For when the warm air of a room heated by a furnace approaches the body, it tends to rise, as the heat of the body is always producing an upward current near its surface. In order that a similar amount of heat may be received throughout the skin, such a room must be therefore kept at a higher temperature than one where heat is thrown out by an open fire. It is also to be noticed that damp air, if hot or cold, conducts heat more rapidly than dry air, which is more healthy in its tendencies. If the air is cold and damp, it will allow heat to escape much too rapidly, unless the skin is very perfectly protected by clothing; cellars and underground rooms are, therefore, always to be avoided as residences, kitchens, offices, lecture-rooms, &c. In the evening more clothing should usually be worn than in the day, because the air is cooler, denser, and the system exhausted: especially is this the case in the early part of summer, when the heat is oppressive in the day, and the skin exhausted by free perspiration.

The health of the glands depends in part upon their natural constitution, and their treatment. Some persons perspire much more easily and freely than others.

Cleanliness of the skin is important on two accounts: that the passages of the excretions may be free, and that they may not be absorbed. For cleanliness the clothing should be frequently changed. That which is worn during the day should be aired during the night. Beds should be daily aired. The skin should be frequently rubbed and bathed—how frequently, will depend upon what is necessary for keeping the skin clean, which is the object. Water alone, or soap and water may be used, as is necessary, convenient, and comfortable. If strong soap is used, it is apt to extract the oil from the skin, which, when dry, will be harsh and will easily chap. In respect to warm or cold applications, two things are to be considered; the first remove the substances from the skin more rapidly, while the second remove heat. If the system can bear the loss, it is frequently benefited by a tonic action of the cold; but if the system is feeble, the loss of heat will sometimes prove fatal, and must be tried with great caution. Boys often, in summer, injure themselves by too frequently bathing in

cool water during a long time. The loss of heat is greater than the system can bear with impunity. Cold baths should never be used so long as to produce chilliness. Vapor baths, if properly used, are the most rapid in action, as it respects softening the accumulations upon the skin, and the most agreeable of all baths in respect to sensations. The vapor should rarely if ever be allowed to act upon the head, but instead, a cool cloth should be applied to it. The feet must be kept warm. The vapor bath should, in health, be continued only till the perspiration begins to start on the face or forehead. After the use of all kinds of baths, the skin should be wiped very dry.*

697. The *Hair and Nails* are peculiar forms of the epidermis. They are by some considered as excretions removed by the skin.

Fig. 276.

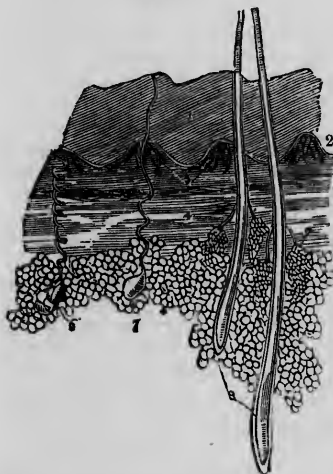


Fig. 277.



Fig. 276. An ideal view of a section of the skin magnified. 1. Epidermis. 2. Basement membrane. 3. Papillae, in which nerves are represented as commencing. 4. True skin, dermis, or cutis. 5. Fat cells. 7. Perspiratory gland. The tube seems to open into a bag, but it is a ball of coiled tube. 8. Roots of hairs. 9. Oil follicles opening into sheaths of hair.

Fig. 277. Longitudinal section of the end of a finger: *f g*, bones; *a d*, epidermis; *b*, nail; *c*, dermis; *e*, fat cells.

Hair is constructed of two parts, the external cylinder, and the internal pith. Each

hair is inclosed in a sheath or cap of epidermis, which passes

* For a still further and very interesting description of the skin and its appendages, and some of the most common diseases to which they are subject, and their treatment, the reader is recommended to a small treatise on the "Healthy Skin," by Erasmus Wilson. It is a very lucidly written work for popular reading, and will well repay perusal; after which it will be valuable as a reference. It has been republished in a cheap pamphlet form, with fine plates, and may be had of the publishers of this work. Price 25 cents.

down into the dermis, and becomes continuous with the hair cylinder. This sheath is surrounded with basement membrane, from which cells grow up at the root of the hair to form the pith. In other words, the sheath of the hair is a deep tubular follicle, from the bottom of which cells are thrown off, but as they adhere, they form a continuous hair, which increases in length as cells are added to its root. To keep the hair in good condition, let its roots be rubbed daily, let the head be occasionally cleaned with castile soap and warm water, and then well dried and rubbed. If the hair require oil, a little may be applied. Often wetting the hair injures it.

The *nail* is only epidermis, the cells of which have undergone peculiar changes, and become similar to those of hair cylinders, or the nail may be considered as hairs devoid of pigment, placed side by side. The nails have an evident use, and so have some of the hairs; but some of them appear useless, except as excretions.

REVIEW OF BOOK II.

A view of the living apparatus of organic life, exhibits a degree of chemical activity, which at once excites the question, For what great object is all this? The answer is, For the purpose of preserving the body in the best condition for the use of the mind in its onward progress through life. For this food is to be masticated, salivated, swallowed, chymified, chylified, lacteated, sanguified. For this purpose, the gastric glands pour out their wonderful fluids, the liver supplies its contributions, and the pancreas yields its elaborations. For this purpose water should be drank and absorbed. For this purpose the heart throbs, and the vitalized streams pour their treasures through the body. For this purpose the dead excretions are borne along with the hurrying currents to where they can be expelled from the body. For this purpose the chest heaves and falls, and the weighty air fills out the lungs.

Thus does the apparatus of organic life serve to sustain that of relation, while the apparatus of relation provides supplies for that of organic life, and is the direct agent of the mind. The body is, therefore, a whole, composed of many parts, designed by the Creator to harmoniously work together; their common purpose is, the elevated development and refinement of the mind, and only when used for this noble purpose, can they be preserved in health, and made most productive of happiness.

APPENDIX.

BLEEDING.

Two things are to be noticed—1st. How we are to know if the bleeding be dangerous. 2d. How to stop it. 1st. Bleeding from the systemic veins is rarely dangerous. The blood that flows in this case, is of a dark red color. The flow will be rather uniform, not in jets, though it may for a few moments be very rapid. Bleeding from any of the large systemic arteries will quickly destroy life. If from the small arteries, it is frequently dangerous. It is known by the bright red color of the blood, and especially by the jetting of the flow. It likewise seems to come from towards the heart. Usually the wound which injures an artery must be a severe one. Sometimes, however, the flow which takes place after leeches have been applied, has destroyed life, especially in case of children. Sometimes also from a slight wound, particularly in the region of the temples, the flow has caused the loss of life. If leeches be applied, or a wound occur in the evening, at least in case of a child, notice should be taken of the state of things, and those who have the care of it should not retire to sleep without every thing is safe. In case of bleeding from the nose, it rarely happens that a blood-vessel is broken, but the flow is caused by the oozing of the blood, so to speak, through the lining of the nose. It is very delicate, and plentifully supplied with blood-vessels. When these become overloaded, their contents sometimes discharge themselves as above said. This is not dangerous unless too frequent or prolonged. Often it is very advantageous.

2d. To stop the flow of blood, it is evident the part which is bleeding should be held as high above the heart as possible, as its action will then be less effective.

Illus.—When the nose is bleeding, the flow is increased if the head be held down.

When, therefore, the arm or hand is injured, it should be thrust upward as far as possible. If the lower extremities be injured, and blood flow too freely, a person should lie down and thrust the foot upward as far as possible. In the next place, it is to be noticed that the blood which flows to either of the extremities is chiefly contained

in one vessel at certain places, as in figs. 224 and 225. 1 1, represents the large artery through which the parts below are supplied.

If pressure be made upon these vessels, and the flow of blood through them stopped, it must cease from the parts below. The situation of the vessels is therefore to be accurately noticed. It will be observed, in case of the arm, that the artery is near by the inner edge of the large muscle on the front part of the arm. In case of the leg, the artery is found between the inner edge of the sartorius muscle, 2 2; (a piece of which has been removed) and the bone. (See also 62, Pl. I.)

If we would make efficient pressure upon these vessels, it is necessary that it should be so made that the blood-vessel shall be between the cause of pressure and the bone.

Sometimes by grasping the limb tightly, with the vessel between the ends of the fingers and the bone, the flow can be stopped. A handkerchief or other strong bandage may be used, after twisting it and tying a knot in the centre. This must be so placed that the vessel is between the knot and the bone. The ends are then to be carried round the limb, and tied in such a manner that a stick or the like may be passed under the bandage directly opposite the knot, and made to twist the bandage till the knot shall forcibly press upon the artery. To aid in this, something not very large may be placed under the knot.

Continued pressure directly on the wound will sometimes stop the flow.

The continued application of cold water will check and sometimes stop the flow.

If an artery of any size has been injured, it must be tied, as the expression is. If the flow stop for a short time, or even several hours, a person should not be satisfied till a ligature has been put upon it, except it is deemed unnecessary by a skilful surgeon.

It is also worthy of notice, that in case of an injury to an artery, the danger is imminent, and something must be done at once, and by a person himself, or the bystanders, while the surgeon is sent for.

F I T S .

Persons are sometimes suddenly taken ill, and become insensible, falling down, sometimes remaining stiff in their seats, sometimes lying still after falling, and sometimes twitching and convulsing. In such a case it will be best to place a person in a reclining position, with the head elevated. Let him receive fresh air, loosen his clothing, and keep him from currents of air. If his hands or feet feel cold, cover and rub them, and make warm applications to them. If the person be convulsed, place him upon the softest convenient thing, and do not attempt to hold him more tightly or carefully than is necessary to prevent his injuring himself or any one. Meantime, of course, the skilful physician should be sent for; and until he advises it, nothing should be given or done in particular, as the causes of the evil and

the nature of it vary so much in different cases, that a person is apt to do much more harm than good by attempting to help the suffering person.

If a physician be not at hand, and the person have eaten indigestive food, either on account of its quantity or quality, give him an emetic.

If a person be subject to fits, let him be very careful about these things:—the kind of food eaten; eat lightly at supper, and not at all just before retiring; let the excretions of the digestive canal be regularly evacuated just before retiring; avoid taking cold, and all causes of nervous excitement, and particularly observe all the directions of a skilful physician in regard to the particular case, for each return of a fit aggravates the evil.

DRUNKENNESS.

In case of intoxication there is increased circulation or congestion of blood in or about the brain. Cold applications to the head, and hot ones to the surface elsewhere, especially to the feet, will somewhat or wholly give relief. A nauseating emetic, mixed in some alcoholic, may also be given for two reasons: to cleanse the stomach, and to excite a dislike for favorite beverages, the effects of which, in large or small quantities, are so fatal to a person's health and all his best interests, and so debasing to humanity.

DROWNING.

The causes of death in case of drowning are twofold: 1st. The loss of heat. 2d. The exclusion of fresh air from the lungs. When a person is plunged under water, the windpipe is at once and involuntarily closed, and of course remains filled with air. The oxygen of this is however quickly exhausted, and it is fully loaded with substance received from the blood. The impurities which should leave the body by way of the lungs, now quickly accumulate, and become deadly poison to the brain and nervous system, the action of which immediately ceases, and returns no more except the person is resuscitated. The time after immersion during which this may be done, depends on many circumstances, but chiefly on the warmth of the water and character of the clothing. The colder the water, the sooner is a person past recovery. But, till long after the surface is quite cold, exertions for restoration should be made.

The first thing to be done, is to carry the drowned person quickly and gently to the most convenient place. Put him in a reclining posture, with the head slightly elevated. The second thing to notice, is the importance of preserving what heat is left, and if possible, adding to it. At once the wet clothes are to be removed, and the person wrapped in flannels. If they are warm, or quite hot, so much the better. Something warm should be put to the chest and abdomen

especially. If no fire is to be had, one or two persons should lie by the side of the drowned, that he may be warmed by the heat of their bodies. The third thing to be noticed is, that the poison must be removed from the blood. For this purpose we must cause pure air to act in the lungs. As they are already more or less filled with bad air, the first thing is, to cause it to be expelled. This is done by pressing gently but forcibly upon the sides and front of the chest and abdomen. Next, we desire to have fresh air pass into the lungs. This may be done by first pressing the upper part of the windpipe downward and backward. The object of this is to keep the windpipe open for the inward passage of the air, which will be produced by removing the pressure made upon the chest and abdomen. The cartilages of the ribs and back, owing to their elasticity, cause the sides of the chest to spring upward and outward, and the inward pressure of the air fills the lungs. Sometimes, however, the inward passage of the air, or some cause, closes the upper part of the pipe. This is recognized by the chest not expanding. In this case the tongue should be drawn forward, as the epiglottis is in part attached to the tongue, and is raised when it is protruded.* If drawing forward the tongue, together with pressing down the larynx, does not leave a free passage for the air, the windpipe must be opened. This is done by drawing the skin tightly across it by means of the thumb and finger, which also, by the same act, hold it firmly. Then cut into it about half an inch below the prominence of the throat, ordinarily called Adam's apple. The opening should be made large enough to insert a tube. For this a quill serves a very good purpose. If no tube be convenient, the sides of the opening made should be spread so as to allow the air to pass freely.

When this part of the process is attended with success, the artificial breathing should be continued a long time, even if no signs of life are seen.

The pressure should be made and removed about twice as often as a person ordinarily breathes. The pressure should be gradually increased and somewhat prolonged, and almost suddenly removed.

The next thing to be noticed is, that if we remove all the poison from the blood in the lungs, this does not affect the blood in the brain, or other parts of the body, except the circulation of the blood be produced. Rubbing, therefore, of the surface is also to be done, but in such a way as not to cool the person at all. It is sometimes of great use in exciting the action of the heart, which, in its turn, acts upon the nervous system, which causes the action of the respiratory muscles. A slight dash of cold water on the face, sometimes excites the nervous system; so will a smart slap with the open hand, or with a switch.

Lastly, we must notice, that nothing but evil would result from

* I have never had the misfortune to be present where a person has required this very simple treatment, since it occurred to my mind; but I have tried numerous experiments on animals, and sufficient to convince me that the above directions will be of great service in many cases.

the use of bellows, or from blowing in a person's mouth. This could not be of any use; the expansion of the chest could not be produced by such means, and can be without them; and they only tend to close the orifice at the summit of the larynx.

CHOKING, HANGING, SUFFOCATION, EFFECTS OF LIGHTNING, &c.

In all cases where there is asphyxia, or suspension of breathing, the same things are to be regarded as in drowning, as danger of death depends upon two things: want of pure air in the lungs, and loss of heat. In choking, which is immediately dangerous, food is detained at the upper part of the œsophagus, and the windpipe is convulsively closed. In public hanging, it is the concussion of the brain, and stoppage of the air, which is fatal, not "the breaking of the neck." In suicidal cases, strangulation is the usual cause of suspended animation, and life can often be restored for some time after apparent death. Suffocation is sometimes caused by covering small children's faces with a cloak or other thick garment—by the falling of earth upon laborers—by a great crowd, which causes such pressure that the chest cannot be expanded—by the inhalation of certain gases, produced by burning coal, &c., or going into wells, vaults, &c. Hundreds of lives might be saved every year, if in all cases of suspended respiration, the means pointed out under the head of "Drowning" should be resorted to. In certain cases of disease of the throat, the breaking of an ulcer is apt to cause convulsive closure of the windpipe to prevent the entrance of improper substances. Sometimes disease in the larynx, or the trachea, closes the passage, and death results from the exclusion of air. In these cases, an opening into the trachea by the physician should not be opposed, for it cannot do any harm, and may save life. In all these cases let it not be thought that life is at once lost; animation is only suspended, and it is best that it should be for the time. If a person should breathe when under water, he could only fill his lungs with water, which would be fatal; therefore the windpipe is instantly closed, and the action of the respiratory apparatus suspended, and the action of the circulatory nearly or altogether stopped.

POISONING.

Poisons may either be introduced into the system from without or generated within it, as we have seen; poisons of a peculiar character also seem, under some circumstances, to be produced by disease. Poisons ordinarily derived from external sources, may enter the system by way of the skin, the lungs, or stomach. In the first place, they should be excluded. 2d. Neutralized. 3d. Diluted. 4th. Evacuated. 5th. Their effects mollified.

That a person may avoid their introduction into the system, it is

necessary, in the first place, that he should recognize them, and the circumstances in which they would be most likely to exist. Knowledge sufficient for such a purpose cannot be given in a work like this; only a few hints can be. Such poisons as children are very likely to obtain should be early shown to them, and their poisonous characters explained—for example: berries of Nightshade, seeds of Apple Peru, the mineral acids, oxalic acid, alkalies, opiates, arsenic, nux vomica, corrosive sublimate, and especially any poisonous roots or wild substances, children will be apt to eat, particularly if they have lived in the city and visit the country.

If such poisons are kept in the house, they should be under a key, placed beyond the reach of children.

The bites of certain animals are poisonous, and poisonous matter is sometimes introduced through the abraded skin by handling decaying meat, or by cutting the skin with a knife while dissecting or skinning an animal. If such work be necessary, the hands should be covered if their skin is not entire.

The air is sometimes filled with poisonous matter exhaled from decomposing animal or vegetable matter. The production of this poison is facilitated by heat and moisture. Houses and places for animals should, especially in hot weather, be located where the air can freely circulate, and away from sources of poisonous exhalations, while those necessarily produced, should be removed to a safe distance. The worst of these poisons are the exhalations from the skin and lungs, which are constant, and can only be provided against by having apartments well ventilated, and not crowded, and the clothing often cleaned and aired. In certain diseases specific poisons are emitted, and fill the air more or less according to the degree of ventilation. To render the sick person least dangerous to his necessary attendants, his apartments should be well ventilated. A peculiar state of the air, which cannot be accounted for, sometimes produces or facilitates the production of disease. It seldom happens that all positions are equally affected. The safest should be chosen. They can be ascertained by observing in what kinds of localities diseases most prevail.

In the second place, it is evident that if the vessels are full, they cannot receive poisons as when they are partially empty. If exposed to the danger of receiving poisons, it is therefore well to drink freely of pure water, e. g., when going into a sick chamber, or when going out in the morning in a malarious district.

2d. There are many things which partially or wholly tend to neutralize the harmful action of certain poisons. But as they would be usually not at hand, and perhaps also not easily remembered, one thing only will be mentioned—eggs should be swallowed as quickly as possible after too large a quantity of corrosive sublimate has been taken. This poison is the usual prominent ingredient of bug poisons. It is so deadly it should not, on any account, be kept in any part of a house, but obtained merely as it is wanted.

3d. Almost all liquid poisons may be diluted by water, which should be swallowed in the greatest quantity, and very rapidly. This

will dilute the poison, distend the stomach, and assist in vomiting, or cause it.

4th. To evacuate the poison, whether it has been neutralized or diluted, or not, is almost always quite necessary. If the poison have been dissolved, this is usually readily done; but if the poison be a powder, or the like, it is apt to adhere to the sides of the stomach. In this case we wish to distend the stomach, so that no poison may be detained in any folds of it; and, in the second place, to pass into the stomach some paste-like or adhesive substance, which, by adhering to the poison, shall bring it out. In such a case, therefore, it is best to stir up a portion of flour or meal in a pint or quart of water till it is as thick as a person can swallow. This he should swallow. If no flour or other similar substance be at hand, water alone may be taken. A tablespoonful of ground or powdered mustard, or a fourth of that quantity of alum may be passed into the stomach in any convenient way; for want of these, or in their stead, water may be rapidly drank, till, by its quantity, it distends the stomach and produces vomiting. (It should not be cold.) A very small quantity of sulphate of zinc will usually act as an emetic (what might be held on a finger nail). Other things will also operate more or less readily as emetics, and according as they are most convenient they can be used. Sometimes the poison, especially if a narcotic, has so acted on the system that a person cannot swallow, or, if he can, that an emetic cannot operate. In this case, it usually happens that the brain is oppressed by the presence of too much blood. To remove this, several things may be done. In case of intoxication, the usual custom has been to pump cold water on the head. Warm applications may also be made to the hands and feet. The system may be rubbed. The person may, if possible, be compelled to take exercise, by placing him between two persons, and walking him up and down, cold cloths being upon his head at the same time. Tingling the skin with a switch is also resorted to. Doses of strong tea and coffee are given. Such remedies should, however, be administered with much care, and never by an unskilful person, for if the person could barely live as it is, the slightest increase of the evil might destroy his life.

QUACKERY AND QUACK MEDICINES.

These might very properly be considered under the head of poisons, for they are so in a double sense. Many, yes, thousands have been carried to a premature grave by tampering with medicines, presented before them by the bland voice of the wolf in sheep's clothing. In the second place, the morals of the undiscerning young are undermined by the exhibition of wealth and apparent success, as it is called, of those who laugh at the credulity of their beguiled victims. This most heinous, dishonorable, and wicked traffic in the love of life and family, which is at present carried on in the community, ought to meet the severest condemnation from every moral, religious, intelligent, or well-wishing member of society.

GLOSSARY.

- AB-DO'MEN** (*abdo*, I hide). That part of the trunk which is between the thorax and pelvis.
- AB-DUC'TOR** (*abduco*, I lead from). A name applied to certain muscles which turn parts of the body outwards from its axis.
- A-CE-TAB'U-LUM** (Roman vinegar-cup). Socket of hip.
- A-CE'TIC** (*acetum*, vinegar). Name of the acid of vinegar. Composed of $C_4H_3O_3.HO$.
- (ACHILLES)** Achillis (Grecian hero). Specific name of the tendon ordinarily called the heel-cord.
- A-CRO'MI-ON** (*ἄκρος*, summit, *ὤμος*, shoulder). Specific name of a process.
- AD-DUC'TOR** (*adduco*, I lead to). Specific name of certain muscles which turn the axis of parts towards that of the body.
- AD'I-POSE** (*adeps*, fat). Belonging to fat.
- AF-FIN'I-TY**, chemical (*affinitas*, relationship). The name given to the attraction which certain different kinds of particles manifest for each other at imperceptible distances.
- AL-BU'MEN** (*albus*, white). Name of an organic element.
- A-LU'MIN-UM**. The name of a chemical element.
- AL'VE-O-LAR** (*alveus*, a deep cup). Belonging to the teeth-sockets.
- AM-MO'NI-A** (uncertain). A compound of $N+3H$. Ammid of hydrogen, volatile alkali.
- AM-PHIB'I-OUS** (*ἄμφι*, both, *βίος*, life). Living in both air and water.
- A-NAS'TO-MOSE** (*ἀνά*, through, *στομῶ*, I form a mouth). To open into each other. (Used in respect to vessels.)
- AN'EU-RISM** (*ἀνά*, through, *εὐρύνω*, I dilate). Unnatural dilatation of an artery, producing a pouch, sac, or tumor.
- AN-GI-OL'O-GY** (*ἀγγεῖον*, a tubular vessel, *λόγος*, discourse). The division of anatomy treating upon the blood-vessels and lymphatics.
- AN'GU-LI** (*angulus*, an angle). Of the angle.
- AN'NU-LI** (*annus*, a year). Ring-shaped.
- AN'TI-CUS** (L. turning toward the axis). Name of certain muscles.
- A-ORT'A** (*ἀήρ*, air, *τηρέω*, I keep). The central arterial trunk. Its name was given when it was thought to contain air.
- A-PON-EU-RO'SIS** (*ἀπό*, from, *νεῦρον*, nerve). Name given to the expanded fibrous tissue connecting muscles with the parts they act upon. Broad tendon. The ancients called all white, cordy parts nerves.
- AP-PA-RA'TUS** (*apparo*, I prepare). A group of organs which contribute to the accomplishment of a function.
- A-RACH'NOID** (*ἀράχνη*, a spider, *εἶδος*, like in form). Specific names given to certain mem-

- branes delicate as that of a spider—(spider's web.)
- AR'BOR-VI'TAE (tree of life). Name given to central part of cerebellum.
- AR'TE-RY (see Aorta). Name of any vessel through which blood flows from a heart.
- AR-TIO'U-LA-TED (*articulo*, jointed).
- A-RYT'E-NOID (ἀρϋτήρ, a ewer or pitcher, ἔρδος, like in form). Name of laryngeal cartilage—the two resembling the nose or lip of an ancient pitcher.
- AS-PHYX'IA (α, deprived of, σφύζω, I throb). Without pulse. Now used to express the condition when the breath is suspended, but life not extinct.
- AS-TRAG'A-LUS (ἄστρογάλλος, ankle bone).
- AT'OM (α, not, τέμνω, I cut or divide). Two meanings. 1st. An indivisible particle of matter. 2d. A particle which cannot be further divided without decomposition. In the last case, atom is a compound, as an atom of water is composed of an atom of hydrogen and an atom of oxygen.
- AUD'IT-O-RY (*audio*, I hear). Belonging to the hearing apparatus.
- AU'RI-CLE (*auris*, the ear). The name of the upper portion of each heart.
- AU-TO-MAT'IO (αὐτός, self, κινώ, I move). Self-moving.
- AX-IL'LA (L.). Arm-pit.
- A-ZOTE' (α, without, ζωή, life). Nitrogen, lifeless air. An element composing about four fifths of the atmosphere.
- BI'CEPS (*bis*, double, *caput*, head). Name of certain muscles with origins or heads.
- BI-CUS'PIDS (*bis*, double, *cuspis*, a point). Name of the two pointed teeth.
- BI-FUR-CA'TION (*bis*, twice, *furca*, a fork). Name given to a division of parts forming a fork.
- BIL'IA-RY (*bilis*, bile). Pertaining to bile.
- BI-PEN'NI-FORM (*bis*, double, *penna*, a pen). Name of muscles in which the fasciculi are arranged on each side of a central tendon like the barbs of a feather on the stem.
- BRACH'I-AL (*brachium*, arm). Pertaining to the arm.
- BRE'VIS (L.). Short, (-ior) shorter, (-simus) shortest.
- BRONCH'US (bronchi, bronchia, bronchea, Pl.) (βρόγχος from βρέχω, I moisten). The name of any air-tube or portion of the wind-pipe below the trachea. This name was given when these passages were supposed to be the course of the fluids on their way to the stomach. The singular, when applied strictly, means that part of the air-tubes between the trachea and their next division, the plural being applied to the tubes below.
- BRON-CHI'TIS. The termination *itis* (the first *i* is pronounced like long *e*) signifies inflammation; but bronchitis means not inflammation of the entire bronchial tube, but is used to indicate an inflammation of the mucous membrane lining the bronchia, and sometimes of the trachea, larynx, and air-cells.
- BUC-CI-NA'TOR (*buccina*, a trumpet). Name of one of the cheek-muscles.
- BUR'SA (Pl. -æ) (L. a purse). The name of a small sac or very large cell, containing a variable quantity of serum, situated where parts would otherwise be injured by friction.
- CÆ'CA (L. blind). Names of ap-

- pendages to the cæcum in certain animals.
- CÆCUM (L. blind). Name of that part of the intestinal canal which is below where the ilium opens into the colon.
- CALX (L. genitive *calcis*, of the heel). Heel.
- CALCI-UM (L.). A simple element, the basis of lime.
- CA-PIL'LA-RY (*capillus*, a hair.) Name of minute tubes.
- CAP'SULE (*capsa*, an inclosed cavity). A membrane inclosing a cavity.
- CARBON (*carbo*, a coal). A simple element, the chief compound of coal.
- CARBON'IC. The termination *ic*, here signifies that carbon in its highest ratio is compounded with oxygen.
- CARDI-AC (*καρδία*, heart). Pertaining to the heart. Orifice of the stomach beneath the heart.
- CAROT'ID (*κάρω*, I induce sleep). Name of arteries through which blood flows to the head. Named by the ancients, who believed that through them sleep was caused.
- CARPUS (L.). Wrist.
- CARTIL-AGE (*cartilago*). Gristle. One of the tissues.
- CAU'DA E-QUI'NA (*caudus*, a tail, *equus*, a horse). The name of the terminal extremity of the spinal cord.
- CAV'A (L.). Hollow. *Vena cava*, name of a large vein.
- CER-E-BEL'LUM (L.). Small brain.
- CER-E-BRUM (L.). Large brain.
- CER-E-BRO-SPI'NAL. Pertaining to both the cerebrum and spine.
- CER-VI-CAL (*cervix*, neck). Pertaining to the neck.
- CHEST. The upper part of the trunk. The thorax, Gr.
- CHLO'RINE (*χλωρός*, green). A gaseous element.
- CHOR'DA, Pl. -Æ (L.). A cord.
- CHO'RI-UM (*χόριον*, skin, leather). The fibrous membrane of the skin.
- CHOROID. Resembling the skin.
- CHYLE (*χῦλος*, juice). The fluid formed in the second stomach.
- CHY-LIF'IC, CHY-LI-FI-CA'TION (*χύλος*, juice, *facio*, I make). The name of the process by which chyle is formed.
- CHYME (*χῦμος*, a thick juice). A semi-fluid or thick, pasty matter, formed in the stomach.
- CHY-MIF'IC, CHYM-I-FI-CA'TION (*χύμος*, thick juice, *facio* I make). The name of the process by which chyme is formed.
- CIL'IA-RY (*cilium*, eyelash). Resembling the cilia.
- CIN-E-RITIOUS (*cinis*, ashes). Resembling ashes (usually in color).
- CLAV'I-CLE (*clavis*, ancient key). Collar bone.
- CL'EI'DO (*κλείς*, a key). Part of the name of a muscle, signifying that it is attached to the clavicle.
- COAG'U-LUM (L.). A clot.
- COC'CYX (*κόκκυξ*, a cuckoo). The extremity of the spinal column, shaped like a cuckoo's beak.
- COCH'LE-A (L. a snail-shell). Snail-shaped.
- CO'LO-N (*κῶλον*, a member). The large canal between the cæcum and rectum.
- CO'MA (*κῶμα*, deep sleep). Lethargy.
- COM-MU'NIS (L.). Common.
- COM-PRES'SOR (*comprimo*, I press together). Name of certain muscles.
- CON-CUS'SION (*concutio*, I shake together). A shaking of parts among or against each other.
- CON'DYLE (*κόνδυλος*, a knuckle). The name of a bony prominence.
- CON-GES'TION (*congestio*, a fulness). An unnatural accumulation of

- fluids, generally blood, in any part.
- CON-JUNC'TI-VA (*conjungo*, I join together). The name of the skin which lines the eyelids and covers the balls.
- CON-STRICT'OR (*constringo*, I bind together). The name of certain muscles.
- CON-TRAC-TIL'I-TY (*contraho*, I draw together). The name of that property of muscular tissue by virtue of which it is contractible.
- COR'A-COID (*κόραξ*, a crow, *εἶδος*, like in form). Like the shape of a crow's beak.
- CO'R-I-ON, CO'R-I-UM (*χόριον*, skin). Name of fibrous layer of the skin.
- COR'NE-A (*cornu*, a horn). Name of the window of the eye.
- COR'O-NA-RY (*corona*, a crown). Encircling like a crown.
- COR'PUS (L.). A body.
- COS'TA (L.). A rib.
- CRA'NI-UM (L.). That part of the skull which incloses the encephalon.
- CRIB'RI-FORM (*cribrum*, a sieve). Resembling a sieve.
- CRÍ'COID (*κρίκος*, a ring, *εἶδος*). Ring-shaped.
- CRU'RAL (*crus*, the leg). Belonging to, resembling the leg.
- CRYSTAL-LINE (*κρύσταλλος*, clear ice). Resembling a crystal in transparency.
- CU'BI-TAL (*cubitum*, the elbow and the fore-arm—also the ulna). Pertaining to the ulna.
- CU'BOID (*κύβος*, a cube, *εἶδος*, like in form). Cube-shaped.
- CU-NEÍ'FORM (*cuneus*, a wedge). Wedge-shaped.
- CUS'PID (*cuspis*, a point). One-pointed tooth.
- CU'TI-CLE (*cutis*, the skin). The external layer of the skin.
- DE-CUS'SATE (*decusso*, I cross like an X). Intersection.
- DEGLU-TÍ'TION (*deglutio*, I swallow). The act of swallowing.
- DEL'TOID (Δ , delta, *εἶδος*, like in form). Delta-shaped.
- DENT'AL (*dens*, a tooth). Pertaining to a tooth.
- DE-PRESS'OR (*deprimo*, I depress). Name of certain muscles.
- DERM'OID (*δέρμα*, skin, *εἶδος*, like in form). Similar in some respects to the skin.
- DE-SCEN'DENS (*descendo*, I descend). Descending. A name applied to parts through which substances descend.
- DI'A-PHRAGM (*διά*, through, *φράσσο*, to break off, defend, separate). An arched partition separating the chest from the abdomen, forming the floor of one and roof of the other. The midriff.
- DI-AS'TO-LE (*διά*, through, *στέλλω*, I contract). That state of the heart and arteries when they are dilated and ready to throw out or move on their contents.
- DI-GAS'TRI-CUS (*δῖς*, twice, *γαστήρ*, stomach). Name given to muscles with two swellings or bodies.
- DI-GES'TION (*digero*, I dissolve). It has two significations; in a limited sense, it is the name of the process which takes place in the stomach. In its more extended sense, it means the entire processes by which food is prepared to enter the blood.
- DIG'IT-US (L.). A finger.
- DIP'LO-E (*διπλός*, double). Name of the cancellated portion of the cranium.
- DOR'SAL (*dorsum*, the back). Pertaining to the back.
- DUCT (*duco*, I lead). A tube; a canal.
- DU-O-DE'NUM (*duodeni*, twelve). The

- upper part or twelve fingers' breadth of the second stomach.
- DURAMA'TER (*durus*, hard, *mater*, mother).
- DYS-PEP'SIA (δύς, bad, πέσσω, I digest). The name of that state in which digestion is bad.
- E-LAS'TIC. Having the property of returning to a former condition when compression is removed.
- EN-AM'EL (*en* and *email*, Fr.). The glazing of the crown of the teeth.
- EN-CEPH'A-LON (έν, in, κεφαλή, hard). The name given to the collective contents of the skull.
- EP-I-DERM'IS (ἐπί, upon, δέρμα, skin). Name of the external layer of the skin.
- EP-I-GAS'TRI-UM (ἐπί, upon, γαστήρ, stomach). Region of the surface of the body near the stomach.
- EP-I-GLOT'TIS (ἐπί, upon, γλωττίς, the glottis). The name of a valve-like cartilage at the tip of the larynx and over the glottis, the cords forming the edge of which are sometimes called tongues.
- EP'I-PLOON (ἐπί, upon, πλέω, I sail). The caul. The omentum major.
- EP-I-THE'LIIUM. The name of the layer forming the free surface of mucous and serous membranes. It corresponds to the epidermis.
- ETH'MOID (ἡθμός, a sieve, εἶδος, like in form). Name of the bone forming the roof of the nose.
- EX-CRE'TION (*excerno*, I separate). Name of the process by which useless substance is removed: and also the name of the substance.
- EX-CRE'TO-RY. Engaged in the process of excretion.
- EX-HALE' (*exhalo*, I breathe out). To send off vapor.
- EX-PI-RA'TION (*exspiro*, I breathe out). The name of the act of expelling the air.
- EX-TEN'SOR (*extendo*, I extend). The name of such muscles as extend any part; opposed to flexor.
- FA'CI-AL (*facies*, face). Pertaining to the face.
- FALX (L. a sickle). The name of the division which separates the halves of the cerebrum.
- FAS'CI-A (L. a band). A partial or entire sheath.
- FAS-CIO'U-LUS, PL. -LI (L.). A small bundle.
- FAUCES (L.). The throat.
- FEM'O-RAL (*femur*, thigh bone). Pertaining to the thigh.
- FE-NES'TRA (L.). A window.
- FY'BRE (*fibra*). A fine, single, slender body with much length but little breadth.
- FY'BRIL. A very minute fibre.
- FY'BRIL'LA. A diminutive of fibril and fibre.
- FY'BRIN. An organic element.
- FY'BRO-. Part of a word, signifying that the thing named is composed in part of fibres.
- FIB'U-LAR (*fibula*, a clasp). Pertaining to the outer bone of the leg.
- FIL'A-MENT (*filum*, a thread). A name of parts having the form of threads.
- FLEX'OR (*flecto*, I bend). Name of muscles which bend parts of the body. An antagonist to extensors.
- FOL'LI-CLE (*follis*, the bag of an ancient bellows). A very small secretory sac or pit.
- FO'RA-MEN (*foro*, I pierce). A small opening.
- FOS'SA (*fodio*, I dig). A trench. Large excavations, wider at the margin than at the bottom.
- FRAE'NUM (L. a bridle). A curb.
- FUNCT'ION (*fungor*, I perform). Office of an apparatus.

- FU'SI-FORM** (*fusus*, a spindle). An adjective describing certain muscles.
- GALL'-CYST** (*κύστις*, a bladder). Gall-bladder.
- GAN'GLI-ON** (*γάγγλιον*, a nerve-knot). A nervous centre. In surgery, a distended bursa, commonly called weeping sinew.
- GAS'TRIC** (*γαστήρ*, a stomach). Pertaining to the stomach.
- GAS-TROC-NE'MI-US** (*γαστήρ*, stomach, *κνήμη*, leg). The name of a muscle of the leg.
- GEL'A-TIN** (*gelo*, I congeal). An organic element; glue.
- GIN'GLY-MUS** (*γίγγυμος*, a hinge). Hinge-like joint.
- GLAND** (*glans*, an acorn). An organ compounded of secretory cells, fibrous tissue, vessels, &c., and adapted to secreting.
- GLE'NOID** (*γλήνη*, shallow socket of a joint, *εἶδος*, like in form). A shallow cavity.
- GLOB'ULE** (*globus*, a ball). A minute ball.
- GLOS'SO-** (*γλῶσσα*, the tongue). Names of which this is a part refer in part to the tongue.
- GLOT'TIS** (*γλωττίς*, glottis). The opening between the vocal cords.
- GLUTE-US** (*γλουτός*, nates). Name of muscles.
- HEM-A-TO'SIN** (*αἷμα*, blood). An essential compound of blood.
- HE-PAT'IC** (*ἥπαρ*, liver). Belonging to the liver.
- HUMER-US** (L.). Upper arm bone.
- HUMOR** (*humeo*, I moisten). Any fluid of the body.
- HY'A-LOID** (*υαλος*, glass, *εἶδος*, like). The name of the membrane inclosing the vitreous humor.
- HY'DRO-GEN** (*ὑδωρ*, water, *γεννάω*, I generate). A simple element, and constituent of water.
- HY'OID** (*υ*, upsilon, *εἶδος*, like in form). U-shaped.
- HY'PO-GLOS-SAL** (*ὑπό*, under, *γλῶσσα*, tongue). Under the tongue.
- IL'E-UM** (*εἶλω*, I wind). Lower portion of second stomach.
- IL'I-AC** (*ilia*, flank). A term applied to parts in the vicinity of the ilium.
- IL'I-UM** (*ilia*, flank). Name of the upper part of the os innominatum or hip bone.
- IN-CI'SORS** (*incido*, I cut). Name of the cutting teeth.
- IN-FRA-SPI-NA'TUS** (*infra*, below, *spina*, spine). Name of a muscle situated below the spine of the scapula or shoulder blade.
- IN-NOM-I-NA'TA** (*in*, not, *nomen*, name). A name of several parts, which of course contradicts its own meaning.
- IN-TER-COST'AL** (*inter*, between, *costæ*, ribs).
- IN-TER-AR-TIC'U-LAR** (*inter*, between, *articulus*, a joint).
- IN-TER-OS'SE-OUS** (*inter*, between, *ossa*, bones).
- IN-TER-VER'TE-BRAL** (*inter*, between, *vertebra*, a bone of the spinal column).
- I'RIS** (L. rainbow). Name of the colored muscular curtain around the pupil.
- IS'CHI-UM** (L.). The lower and back part of the innominatum.
- JE-JU'NUM** (*jejuno*, I fast). Name of the second stomach between the duodenum and ileum.
- JU'GU-LAR** (*jugulum*, the collar bone and space above it).
- KNEE'PAN**. The patella; the rotula; one of the sesamoid bones on a large scale.
- LA'BI-UM** (L.). Lip.
- LAB'Y-RINTH** (*λαβύρινθος*, a maze). The internal ear.
- LACH'RY-MAL** (*lachryma*, a tear). Pertaining to the tears.

- LAC'TE-AL (*lac*, milk). Name of lymphatic tubes which take up the chyle.
- LAC'TIC A'CID (*lac*, milk). An acid produced when "milk sours;" product from the sugar of milk.
- LAM'I-NA (L.). A thin plate or stratum.
- LAR'YNX (λάρυγξ). The upper part of the windpipe.
- LAR-YN-GI'TIS. A term signifying inflammation of the mucous membrane of the larynx.
- LA-TIS'SI-MUS (*latus*, broad). Broadest.
- LENS (L. a bean). A glass, shaped like flat round beans.
- LE-VA'TOR (*levo*, I raise). Name of certain muscles which raise parts of the body.
- LIG'A-MENT (*ligo*, I bind). A name of the fibrous tissue which binds the bones together.
- LIN'E-A (L.). A line.
- LIN'GUA (L.). The tongue.
- LIV'ER (Sax. *lifre*, heavy). The heaviest gland in the body.
- LOB'U-LUS (*lobos*, a lobe). A small lobe.
- LON'GUS, -GIOR, -GISSIMUS (L.). The Names of certain muscles, dependent on their comparative length.
- LUM'BAR (*lumbus*, a loin). Pertaining to the loins.
- LYMPH (*lympa*, pure water). An almost colorless fluid.
- LYM-PHAT'IC. A tube through which lymph moves.
- MAG-NE'SI-UM (L.). One of the simple elements, which has the general appearance of silver.
- MAL-LE-O'LUS (*malleus*, a mallet). The ankle.
- MAG'NUS (L.). Great.
- MA'JOR (L.). Greater.
- MAN'GA-NESE. The name of one of the simple elements.
- MAR'ROW. The fat in bones.
- MAS'SE-TER (μασσομαι, I chew). Name of a muscle.
- MAS'TI-CATE (*mastico*, I chew).
- MAX'IL-LA-RY (*maxilla*, a jaw). Pertaining to a jaw.
- MAX'I-MUS (L.). Greatest.
- ME'A-TUS (*meo*, I pass). A passage.
- ME-DI-AS'TI-NUM (L.). A name given to the pleuræ where they unite, and to the spaces between them.
- MED'UL-LA-RY (*medulla*, marrow). Pertaining to marrow; also the white portion of nervous substance.
- MES'EN-TER-Y (μέσος, middle or between, έντερον, intestine). That part of the peritoneum which is between the intestine and back wall of the abdomen.
- MET-A-CAR'PAL (μετά, added to, καρπός, wrist). Pertaining to that part of the hand between the wrist and hand.
- MET-A-TAR'SAL (μετά, added to, ταρσός, ankle). Pertaining to the metatarsus.
- MID'RIF. The diaphragm.
- MIN'I-MUS (L.). Smallest.
- MI'NOR (L.). Less.
- MI'TRAL (*mitra*, a turban). Mitre-shaped.
- MO'DI-O-LUS (a cylindrical borer with a serrated edge). The centre of the cochlea.
- MO'LAR (*mola*, a mill). Name of the grinding teeth.
- MOL'LIS (L.). Soft.
- MO'TOR-Y (*moveo*, I move). Concerned in the production of motion.
- MU'COUS (L. *mucus*). Pertaining to mucus.
- MUS'CLE. Proper name of distinct parts of lean meat.
- MY-O'PI-A (μύω, I shut, ὤψ, the eye). Short-sightedness.
- NAR-COT'IC (ναρκώω, I benumb). The name applied to whatever induces sleep.

- NA'SAL (*nasus*, the nose). Pertaining to the nose.
- NER'VOUS (*nervus*, a nerve). Pertaining to nerves.
- NEU-RAL'GI-A (*νεῦρον*, nerve, ἄλγος, pain). Name of some disease of the nerves in which the pain is very severe.
- NEU-RI-LEM'MA (*νεῦρον*, nerve, λέμ-μα, sheath).
- NÝGRUM (L.) Black.
- NÝTRO-GEN (*νίτρον*, nitre, γεννᾶω, I produce). Azote.
- NÚCLE-US (*nux*, a nut). A centre about which matter is gathered.
- NU-TRI'TION (*nutrio*, I nourish). Name of the substance, and also of the processes, by which the body is nourished.
- OB-LÍ'QUUS (L.). Oblique.
- OB-TU-RA'TOR (*obturo*, I stop up). Name of certain muscles.
- OC-CIP-I-TAL'IS (*ob*, back, *caput*, head). Pertaining to the occiput or back part of the head.
- OC-U-LO'RUM (*oculus*, eye). Of the eyes.
- Œ-SOPH'A-GUS (*οἶω*, I carry, φάγω, I eat). Name of the tube through which substances pass from the pharynx to the stomach; meat-pipe; gullet; swallow, &c.
- O-LEC'RA-NON (*ὠλένη*, the elbow, κρᾶνον, a hard point). Name of the hook-like process which forms the point of the elbow.
- OL-FAC'TO-RY (*olfacio*, I make to smell). Assisting in the production of odors.
- O-MEN'TUM (L. adipose membrane). The caul; epiploon.
- OMO- (*ὤμος*, shoulder). Terms in part compounded of this are applied to parts connected with the shoulder.
- OPTIC (*ὤψ*, the eye). Pertaining to sight.
- OR-BIC'U-LAR (*orbis*, a circle). Circular.
- OR'GAN. A part of the body which has a definite and particular use.
- OR'I-GIN (*origo*, first source). That part of a muscle which is usually fixed.
- OS (L.). A bone; a mouth.
- OS'MA-ZOME (*ὀσμή*, smell, ζωμός, broth). Name of the substance which produces the odor, and to a certain degree the flavor, of cooked meat.
- OS'SE-OUS. Pertaining to bones.
- OS-SI-FI-CA'TION (*os*, bone, *facio*, I make). Name of the process by which bones are made.
- OT'O-LITHES (*oûs*, ear, λίθος, stone). Calcareous substances or powder found in the labyrinth.
- O-VA'LE (*ovum*, an egg). Egg-shaped.
- OX'IDE. A compound of oxygen and some other substance or substances.
- OX'Y-GEN (*ὀξύς*, acid, γεννᾶω, I generate). The name of one of the simple elements.
- PA-LA'TUM (L.). Palate.
- PAL'MAR (*palma*, palm). Pertaining to the palm.
- PAL-PE-BRA'RUM (*palpebra*, eyelid). Of the eyelids.
- PAN-CRE-AT'IC (*πᾶν*, all, κρέας, flesh). Pertaining to the pancreas.
- PA-PIL'LA (L.). A small conical eminence.
- PA-RAL'Y-SIS (*παράλυω*, I palsy). The name of any state of any part of the nervous system in which it is incapable of action.
- PA-REN-CHÝ'MA (*παρεγχέω*, I pour in by the side). The tissue of a gland.
- PA-RI'E-TAL (*paries*, a partition wall). Pertaining to the walls of any part. Name of two bones of the skull.
- PA-ROT'ID (*παρά*, near, *oûs*, the ear). Name of one of the salivary glands.

- PEO'TO-RAL (*pectus*, breast). Pertaining to the front part of the chest.
- PE'DIS (*pes*, foot). Of the foot.
- PEL'VIS (L. a basin). That part of the body included by the hip bones.
- PEN'NI-FORM (*penna*, a pen). A name given to muscles in which the fasciculi are arranged on one side of a tendon.
- PER-I-CAR'DI-UM (*περί*, about, *καρδία*, the heart). Heart-case.
- PER-I-CHON'DRI-UM (*περί*, about, *χόνδρος*, cartilage). Membrane about the cartilage.
- PER-I-CRA'NI-UM (*περί*, about, *κράνιον*, the cranium). Membrane about the cranium.
- PER-I-OS'TE-UM. Membrane about the bones.
- PER-I-TO-NE'UM (*περί*, about, *τονόω*, I stretch). Name of the serous membrane lining the abdomen and forming the surface of many of its organs.
- PER-O'NE-US (*περόνη*, a clasp, the fibula). The name of several muscles.
- PER-SPI-RA'TION (*per*, through, *σπиро*, I breathe). Excretion of the skin.
- PHAL-AN'GES (*φάλαγξ*, a phalanx). The rows of bones of fingers or toes.
- PHA-RYN'GE-AL (*φάρυγξ*, pharynx). Pertaining to the pharynx.
- PHOS'PHO-RUS (*φῶς*, light, *φέρω*, I bear). One of the simple elements.
- PHREN'IC (*φρήν*, the midriff). Pertaining to the diaphragm, the name being given when it was thought the seat of the mind was there.
- PI'A MA'TER (L. soft mother). Membrane next the brain.
- PIG'MENT. Paint.
- PR'SI-FORM (*pisum*, a pea). Pea-shaped (and sized).
- PIT-U'I-TA-RY (*pituita*, rheum). Name of the membrane lining the nose.
- PLA-TYS'MA (*πλατύς*, broad). The name of a neck muscle.
- PLEU-RI'TIS (*πλευρά*, pleura). Inflammation of the pleura; pleurisy.
- PLEX'US (*plecto*, I weave). A network.
- PNEU-MO-GAS'TRIC (*πνεύμων*, lung, *γαστήρ*, stomach). Pertaining to the lungs and stomach.
- POL-LI'CIS (*pollex*, the thumb or great toe).
- PONS (L.). A bridge.
- POP-LITE-AL (*poples*, the ham of the knee; the hough). Pertaining to the posterior part of the knee joint.
- POR'TIO DU'RA and MOL'LIS (L.). Hard and soft part of the 7th or 7th and 8th pairs of nerves, facial and auditory.
- PO-TAS'SI-UM (L.). A simple element, the base of potash.
- PROC'ESS (*processus*). A prominence of bone.
- PRO-FUND'US (L.). Deep.
- PRO-NATOR (*pronus*, downward). Name of a muscle which turns the palm down.
- Pso'AS (*ψοαι*, the loins). Name of muscles reaching from the loins to the thigh.
- PUL'MO-NA-RY (*pulmo*, lung). Pertaining to the lung.
- PULSE (*pulsus*, a stroke).
- PUPIL. The opening in the iris; the apple of the eye.
- PY-LO'RUS (*πύλωρος*, a gate-keeper). The name of the thick band of muscular fibres about the outlet from the stomach.
- PYR-A-MI-DAL'IS. Name of muscles.
- QUAD-RA'TUS. A name of square or oblong muscles.

- RA-CHID'I-EN (*ράχis*, the spine). Name of the spinal canal.
- RA'DI-US (L. a ray). Name of one of the bones in the lower arm.
- RAM-I-FI-CA'TION (*ramus*, a branch, *facio*, I make). The act of branching.
- REC'TUM (*rectus*, straight). The last part of the digestive canal.
- RE-SPIR'A-TO-RY (*re*, again, *spiro*, I breathe). Pertaining to respiration.
- RET'I-NA (*rete*, a net). The terminations of the optic nerve in the eye.
- RO-TUN'DUM (L.). Round.
- RU'GA (L.). A wrinkle; a fold.
- SA'CRAL. Pertaining to the sacrum, or bone situated between the hip bones and supporting the spinal column.
- SA'CRO-. A term applied to parts connected with the sacrum.
- SAN-GUIF'IC (*sanguis*, blood, *facio*, I make). Blood-making.
- SAPH'E'NA (*σάφης*, manifest). Name of veins.
- SAR-TO'RI-US (*sartor*, a tailor). Name of a muscle.
- SCA'LA (L. an ascending path). Cavity of the cochlea.
- SCA-LE'NUS (*σκάληνός*, unequal). Name of muscles.
- SCAPH'OID (*σκάφη*, a skiff, *ειδος*, like). Name of a wrist bone.
- SCAP'U-LAR (*scapula*, shoulder-blade). Pertaining to shoulder-blade.
- SCARF-SKIN. Cuticle; epidermis; outer layer of skin.
- SCHNEI-DE-RI-AN (Schneider, a man's name). The name of the membrane lining the nose; pituitary membrane.
- SCI-AT'IC (*ischion*, the hip). Name of the large nerve of the hip and thigh.
- SCLE-ROT'IC (*σκληρός*, hard). Name of outer coat of the eye.
- SE-CRE'TO-RY (*secerno*, I separate). Pertaining to the process of secretion.
- SE-CUN'DUS (L. second). Name of certain muscles.
- SEP'TUM (*sepes*, a hedge). A division.
- SE'ROUS. Pertaining to serum.
- SER'RA TUS (*serro*, I saw). Name of a muscle.
- SES'A-MOID (*σήςαμον*, sesame-seed, *ειδος*, like). Name of certain bones.
- SIG'MOID. Resembling the sigma (Σ) of the Greeks.
- SIL'I-CON. A simple element, and base of silex.
- SI'NUS (*sinum*, a drinking-vessel with swelled sides). A cavity the base of which is larger than its outlet.
- SKEL'E-TON (*σκέλλω*, I dry up). The framework of an animal.
- SO'DI-UM. A simple element and base of soda.
- SO'LE-US (*solea*, a sole-fish). A muscle of the leg.
- SPHE'NOID (*σφήν*, a wedge, *ειδος*, like). The name of a cranial bone.
- SPHINC'TER (*σφίγγω*, I shut close). The name of ring muscle about any opening.
- SPINE. A thorn; a sharp prominence of bone.
- SPLEN'IC. Pertaining to the spleen.
- STER'NUM (*στέρνον*, the breast). The breast bone.
- STRA'TUM (*sterno*, I spread out). A layer.
- STRI'A. A stripe or streak.
- STY'LOID (*στυλος*, a long, slender pillar, *ειδος*, form).
- SUB. A prefix signifying under.
- SU-PE-RI-O-RIS. Name of certain muscles.
- SU-PI-NA'TOR (*supinus*, with the face upward). Name of muscles which turn the palm up.

Minfield

- SU'TURE (*suo*, I sew). The name of certain joints.
- SYN-O'VI-A (*σύν*, with, *ὠόν*, an egg). Name of the fluid that lubricates the joints.
- SYS'TO-LE (*σύν*, with, *στέλλω*, I contract). The state of the heart when it is contracted.
- TAR'SAL (*tarsus*, the ankle). Pertaining to the ankle.
- TEN'DON (*τείνω*, I stretch). The name of fibrous tissue when in the form of cords.
- TEN'SOR. Name of a muscle that makes any part tense.
- TEN-TO'RI-UM (*tendo*, I stretch). The dense membrane stretched between the cerebellum and cerebrum.
- TE'RES (L. round). Name given to parts of a round shape.
- THO-RAO'IC (*θώραξ*, chest). Pertaining to the chest.
- THY'ROID (*θῦρεός*, a shield, *εἶδος*, like). A cartilage of the larynx.
- TIB'I-AL (*tibia*, a flute, the large bone of the leg). Pertaining to the tibia.
- TRACH'E-A (*τράχης*, rough). That portion of the air-tubes which is between the larynx and bronchi.
- TRA-PE'ZI-US (*τραπέζιον*, an irregular four-sided figure). The name of a muscle; the cucullus.
- TRI'CEPS (*tres*, three, *caput*, head). Name of muscles.
- TROCH'LE-A (*τροχᾶλία*, a pulley).
- TRI-CUS'PID (*tres*, three, *cuspis*, point.) Three-pointed.
- TRO-CHAN'TER (*τροχάω*, I roll). Name of large processes of the thigh bone.
- TUR'BIN-A-TED (*turbo*, a top). Names of bones shaped like part of a top.
- TU'BER-CLE (*tuber*, a bunch). A small prominence on the bones.
- TU-BER-OS'I-TY. A knobbed state of a bone.
- TYM'PA'NUM (L. a drum). The middle ear.
- UL'NAR (*ulna*, the elbow; also a bone which assists to form it). Pertaining to the ulna.
- UN'CI-FORM (*uncus*, a hook). A bone of the wrist.
- U-VE'A (*uva*, a grape). Name of membrane forming back surface of the iris.
- U'VU-LA (L. small grape). The hanging point in the back of the mouth.
- VAS'CU-LAR (*vas*, a vessel). Pertaining to or abounding in vessels.
- VAS'TUS (large). Name of certain muscles.
- VERM-I-FORM'IS (*vermis*, a worm). Having the form of a worm.
- VER-TE'BRA (*verto*, I turn). A bone of the spinal column.
- VES'I-CLE (*vesica*, a bladder).
- VES'TI-BULE (*vestibulum*, a court of a house). A part of the labyrinth of the ear.
- VIL'LI (*villus*, a hair). Minute papillæ.
- VIT'RE-OUS (*vitrum*, glass). A humor of the eye.
- VO'MER (L. a ploughshare). Division bone of the nose.
- XYPH'OID (*ξίφος*, a sword, *εἶδος*, like). The sternal cartilage.
- ZYG-O-MAT'IC (*ζυγόν*, a yoke). Name of a process of the temporal and malar bones.